Highlights

- High Resolution Remote Sensing Data
- Articles from Fiji, Kiribati, Kosrae, Marshall Islans, New-Caledonia, Niue, Samoa

Highlights

- Different GIS Applications
- Remote Sensing Techniques
- Vegetation Monitoring

Pacific Islands

GIS/RS *news*

The Newsletter of the GIS/Remote Sensing Users in the Pacific
Issue 2 /2001

High-resolution satellite images improve GIS of Pacific Island Countries......

This year, we have assisted in many projects in Remote Sensing using the latest generation of high-resolution satellite imagery available to the Pacific market. In addition we have continued to keep the GIS/RS users forum well informed on the new generation and availability of new satellite imagery as it happens:

1) **QuickBird2, launched October 18, 2001**
2) **OrbView-4, launched 21 September, but did reach the orbit**
3) **EROS-A1 delivers quality panchromatic data**
4) **IKONOS really hits the market in the Pacific**

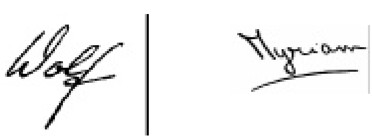
Remote sensing applications continue to expand in many Pacific Island Countries, and IKONOS image data is the most in demand.

SOPAC as a regional organisation has developed the technical expertise in producing georeferenced high-resolution images, IHS pan-sharpened images and change-detection images. To date, SOPAC supports many requests to generate such images and delivers these as GIS backdrops that have been used for different projects such as for vegetation mapping and change detection, coastal erosion, lagoon mapping and reef monitoring in Kosrae, Federated States of Micronesia, Majuro Atoll, Marshall Islands, Tongatapu, Tonga and, most recently, Manihiki Atoll in the Cook Islands.

Although only two issues of the GIS/RS newsletter were published this year, GIS and remote sensing news and activities have been promoted through numerous workshops given around the Pacific.

This newsletter provides you with an overview of the use of IKONOS imagery for Majuro in a study of vegetation change and detection, and in Kosrae we highlight the application of the imagery for vegetation monitoring.

As we wanted to have this issue of the newsletter published for the annual GIS/RS Conference, with the short time available to the editorial team you may read and find some articles do not quite conform to BBC English but nevertheless you will find the articles are excellent and informative as to how imagery is being used in, and where in the Pacific. In our next issue look forward to seeing how high-resolution imagery and multibeam seafloor imagery are being combined to develop an island system management GIS tool.



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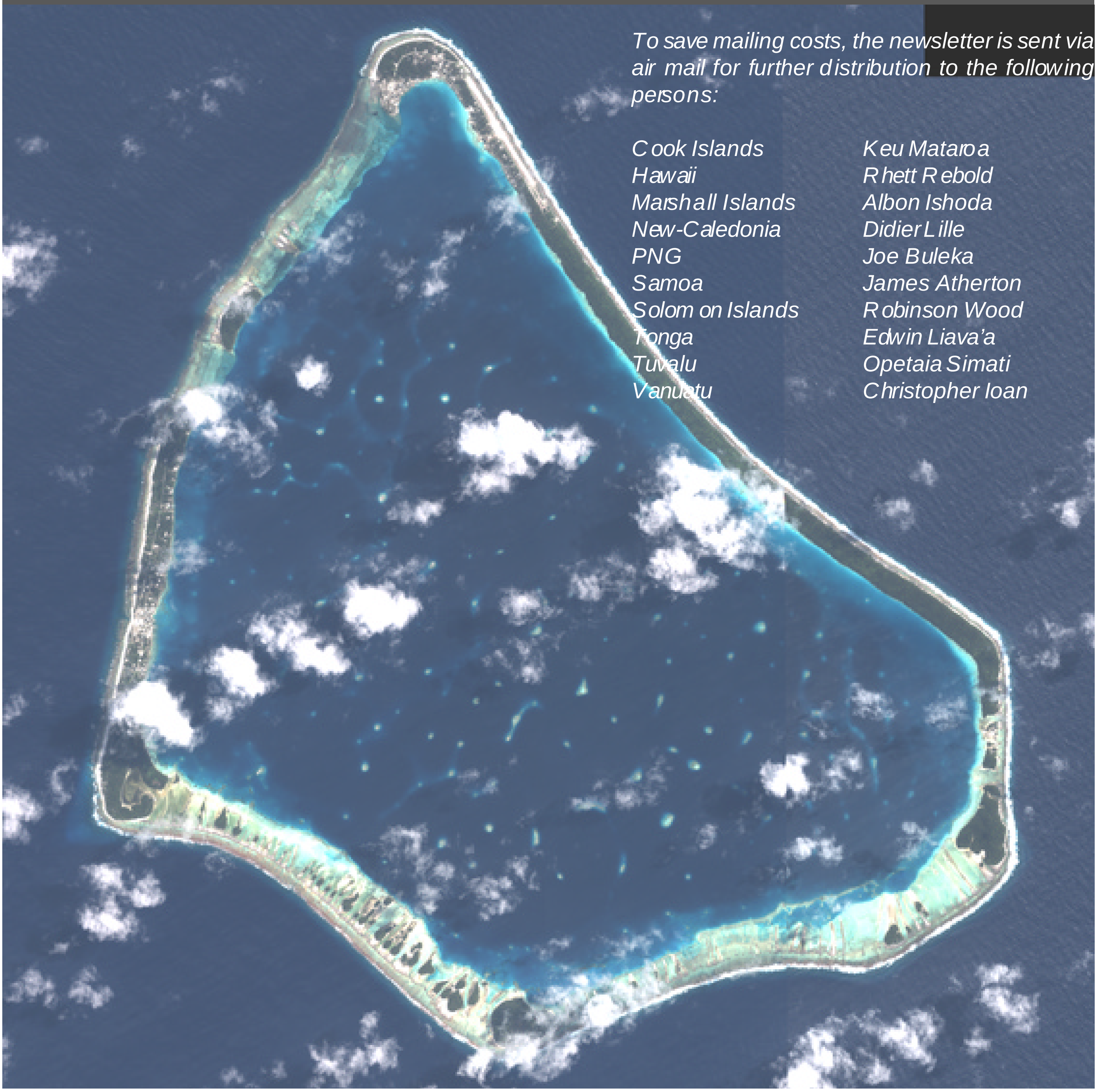

To save mailing costs, the newsletter is sent via air mail for further distribution to the following persons:

Cook Islands	*Keu Mataroa*
Hawaii	*Rhett Rebold*
Marshall Islands	*Albon Ishoda*
New-Caledonia	*Didier Lille*
PNG	*Joe Buleka*
Samoa	*James Atherton*
Solomon Islands	*Robinson Wood*
Tonga	*Edwin Liava'a*
Tuvalu	*Opetaia Simati*
Vanuatu	*Christopher Ioan*

Vegetation Change Detection Using IKONOS Image

IKONOS Image Data Employed for Vegetation Change Detection in Majuro

Albon Ishoda, EPA - Marshall Islands

Introduction

AusAID is currently funding the establishment of GIS in the Republic of Marshall Islands. The project is carried out by SOPAC. One part is vegetation cover mapping and the necessary introduction of hardware, software and technique, enabling Marshall Islands to monitor the flora. A decrease of vegetation can be an indicator of saltwater infiltration to the freshwater body due to sea level rise.

Figure 1: *GPS survey of vegetation boundaries as GCP replacement*

The IKONOS Image

The multispectral IKONOS image was recorded in 2000. It covers the blue, green, red and near infrared portion of the spectrum and arrived as geocoded 11 bit image data.

The first part of the AusAID funded GIS project established a GIS including an own base station, which was used to check the geometric accuracy and geometrically correct the image data. The geometric correction was performed using ERDAS rubbersheet module employing more than 100 ground-control points. These ground-control points were mainly identified through GPS road and sea wall survey. For the outer islands of the Majuro lagoon vegetation boundaries were surveyed with the GPS rover.

Mapping the Vegetation with Aerial Photographs recorded 1983

The coloured aerial photographs were recorded in 1983. Copies were identified in the SOPAC archive,

Figure 2: *Shelter Island of Majuro Lagoon with GPS surveyed vegetation boundaries displayed after image rectification.*

scanned and geometrically rectified. The geometric rectification was performed again by ERDAS rubbersheet module using available GPS road network and seawalls as Ground Control Points (GCPs). In many cases the rectified IKONOS image provided the reference and vegetation pattern and buildings acted as GCPs.

The delineation of vegetation was carried out in MapInfo environment after converting the rectified photographs to GIS image backdrops. The scanning at 600 dpi provided sufficient resolution to use the texture information for recognising vegetation pattern. This was essential as some photographs were only available as black and white copies.

Mapping the Vegetation with the IKONOS Image

ERDAS is able to import 11-bit data, however, such data is handled as 16-bit dataset, which cannot be transferred to readable TIFF files. A conversion to 8-

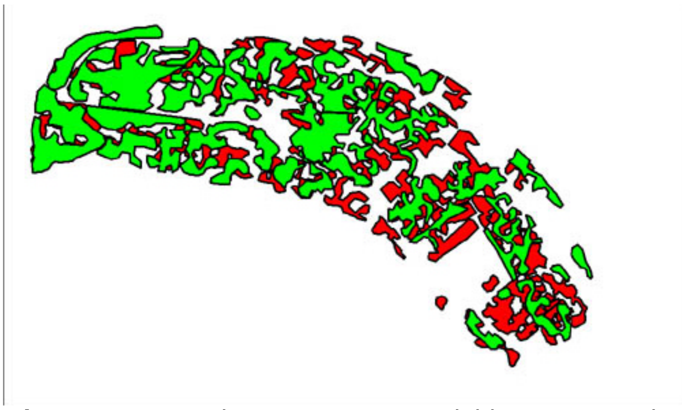

Figure 3: *Vegetation cover 2000 overlaid over vegetation cover in 1983. Red indicates removed vegetation.*

bit data images is necessary before converting from ERDAS internal IMG format to GeoTIF.

Before this step was carried out, the channels near infrared, red and green were selected for the vegetation analysis equal to a false colour infrared photograph. Then an Area Of Interest (AOI) was digitised which only contained different types of vegetation, some houses and excluded beach, shallow or deep water. The image stretch of this AOI (standard deviation stretch) was not only employed for the complete image in the form of a look-up table, but ERDAS also provides the possibility to recalculate the image data due to the contrast stretch. By performing this the 11-bit data range is reduced to 8-bit data without loosing necessary image content.

The image interpretation was performed in MapInfo environment after importing the resulting GeoTIF

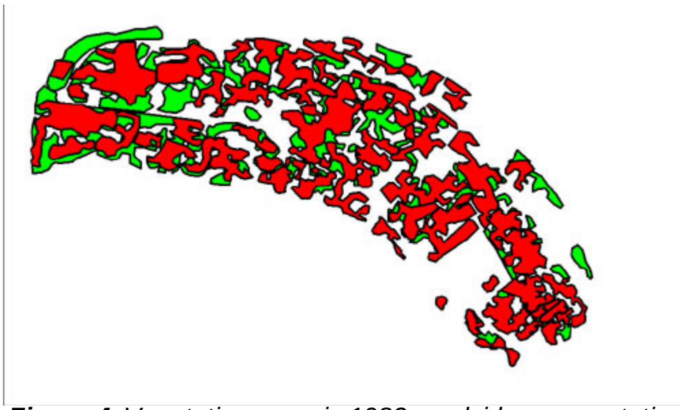

Figure 4: *Vegetation cover in 1983 overlaid over vegetation cover in 2000. Green indicates new vegetation areas.*

image to GIS backdrop. The interpretation was based on the colour difference between vegetation and no vegetation in the infrared band. Due to the spatial resolution of 4m texture, vegetation pattern could not be used. The smallest unit to be shown on the map was limited to about 15m diameter.

Fieldwork and Results

So far, the fieldwork was limited to the Rita village in the north of Majuro. The fieldwork verified the delineation of vegetation boundaries, with one exception where weed had an intensive reflection in the infrared, but could not be considered as dense vegetation. Breadfruit trees showed strong reflection in the infrared indicated by intensive red colour. Other dense vegetation of different species was indicated by darker red. Areas just covered by grass could be separated by a more pink colour.

Figure 5: *Fieldwork is essential for any vegetation mapping. This weed indicated dense vegetation by its strong reflection in the near IR. After field visit this area was removed from the rest of the vegetation cover.*

Geospatial Data Integration and Visualisation

To make life easy the MapInfo tables of both the vegetation cover from 1983 and 2000 were exported from MapInfo to Excel and summarised in office environment. Surprisingly there was not much difference in area covered by vegetation in Rita, although the number of houses increased substantially during the last 17 years. This is due to the fact that there are many areas where palms and other trees have been planted.

Recommendation

It is possible to carry out vegetation monitoring within a Pacific Island Country if a small GIS unit is installed including GPS and basic remote sensing software. Vegetation decrease is an essential indicator of human resource overuse. It also can act as an indicator of change in water quality and availability especially in low atoll islands. This AusAID project is the first project to establish a GIS unit containing remote sensing facilities to carry out geometric image correction and image contrast enhancement. This is necessary for vegetation monitoring. The model should be transferred to other Pacific Island Countries.

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Geospatial data integration and visualisation using open standard

Gilles Taladoire, Touraivane
UNC-IRD LATICAL

1- Introduction and context

First, we will present the context of our work with the localisation and the participants. Then, after a presentation of the global project, we describe the data description languages GML and SVG.

The works are managed by the "Université de La Nouvelle Calédonie" (University of New Caledonia - UNC) and the "Institut de Recherche pour le Développement" (IRD).

The UNC is a very small French university in New Caledonia, an island in South Pacific between Australia and New Zealand. The computer sciences team work on the theme "Computer Sciences for the environment". For that, they collaborate with geographer and geologist to integrate multidisciplinary knowledge for the management of the environment.

The IRD is a French multidisciplinary research institute with 3 main themes in New Caledonia : marine environment, terrestrial environment and society. His research focuses on natural and human environments in tropical island. The different locations of the research unit ESPACE constitute a very powerful network for tropical study and satellite reception station : French Guyana (South America), La Réunion (Indian Ocean), Orléans (France), Montpellier (France) and New Caledonia (Pacific Ocean).
The goal of the collaboration between UNC and IRD is to develop Environmental Information System for a sustainable development.

2- Environmental Information System

Lot of systems participate in the management of environmental data. This systems can be broken down into :

- acquisition from aerial images, satellite images, ground sensor, …
- data archiving including conception, storage and extraction,
- data processing and analysis,
- data visualisation for each kind of user, graphically on the web.

Very often these systems are independent and end in incompatibility or incoherence in this processing chain. Automation is then difficult or impossible. More over, generally many partners are involved in environmental projects (expert firm, administration, research

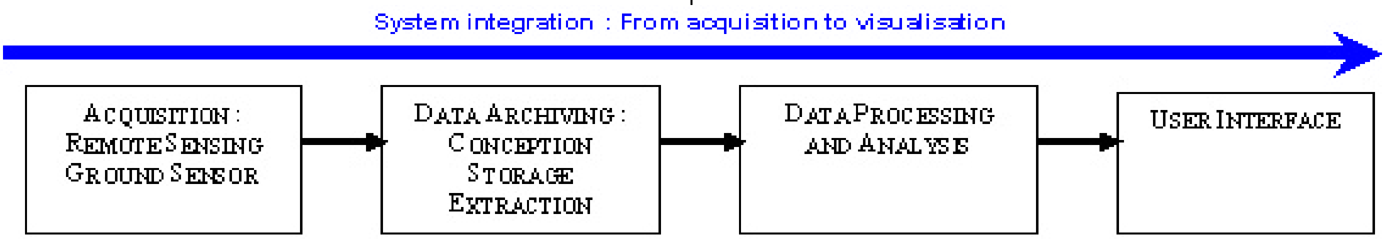

Figure 2-1: Integration System : From acquisition to visualisation

institute, …). Probably, they don't use the same methods, the same software in a single place. We have heterogeneous data on many places. With this observation, we need to propose methods to connect together this different information systems along the process : from acquisition to visualisation.

Let us described briefly each component of the global process.
Data acquisition is the beginning of any environmental process. This acquisition can be done with satellite sensor, with aerial sensor, with ground sensor. Each application or material give data without standard.
Data archiving is fundamental for the data preservation and usage. This process includes the conceptual modelling, the storage and the extraction of the data. Different models are used, different system are used (Geographical Information System - GIS or Data Base Managment System - DBMS) with their particularities.
Data processing and analysis is the useful part. The data archiving must be used to supply data to other systems and to be supplied with process data. The systems to be connected can be expert systems, neural networks, multi-agents systems, data mining systems, image processing and analysis, simulations, scientific model, … Each system has his own data format.
Visualisation is the final process. The visualisation must be adapted to the different users of an environmental project : scientific and expert, decision maker, teacher and student, general public, … The information must be available on Internet, usually with graphics.

We note that we need to make collaborate these different systems to use the data efficiently and to automate operations like acquisition, archiving, processing, …

3- Existing initiatives

In the domain of the internet, we note the World Wide Web Consortium (W3C) initiative. The W3C develops interoperable technologies (specifications, guidelines, software, and tools) to lead the Web to its full potential as a forum for information, commerce, communication, and collective understanding. Among this technologies, we are interested by the Extensible Markup Language (XML) [XML10] which is the universal format for structured documents and data on the Web. An application of XML developed by the W3C for describing two-dimensional graphics is SVG (Scalable Vector Graphics) [SVG].
In the domain of geospatial information, we note two standardisation initiatives which collaborate together for some points : the OpenGIS consortium [OGC] and the technical comity ISO 211 [ISO211].
The aims of the Technical Comity ISO 211 is the standardisation in the field of digital geographic information. For that, it will be established a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth.
The objective of the OpenGIS project is to define transparent access to heterogeneous geodata and geoprocessing resources in a networked environment. For that, the OpenGIS Project will provide a comprehensive suite of open interface specifications that enable developers to write interoperating components that provide these capabilities. Among these specifications, we are interested by GML (Geographic Markup Language) [GML20].

For later use in the document, we describe shortly GML and SVG.

3.1- GML (Geographic Markup Language)

The Geography Markup Language (GML) [GML20] (or in French Error! Reference source not found.) is an XML encoding for the transport and storage of geographic information, including both the spatial and non-spatial properties of geographic features. This specification defines the XML Schema syntax, mechanisms, and conventions that :

- Provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects;
- Allow profiles that support proper subsets of GML framework descriptive capabilities;
- Support the description of geospatial application schemas for specialized domains and information communities;
- Enable the creation and maintenance of linked geographic application schemas and datasets;
- Support the storage and transport of application schemas and datasets;
- Increase the ability of organisations to share geographic application schemas and the information they describe.

Implementers may decide to store geographic application schemas and information in GML,or they may decide to convert from some other storage format on demand and use GML only for schema and data transport.

The OGC Abstract Specification [OGC99] defines a geographic feature as *"an abstraction of a real world phenomenon; it is a geographic feature if it is associated with a location relative to the Earth".* Thus a dig-

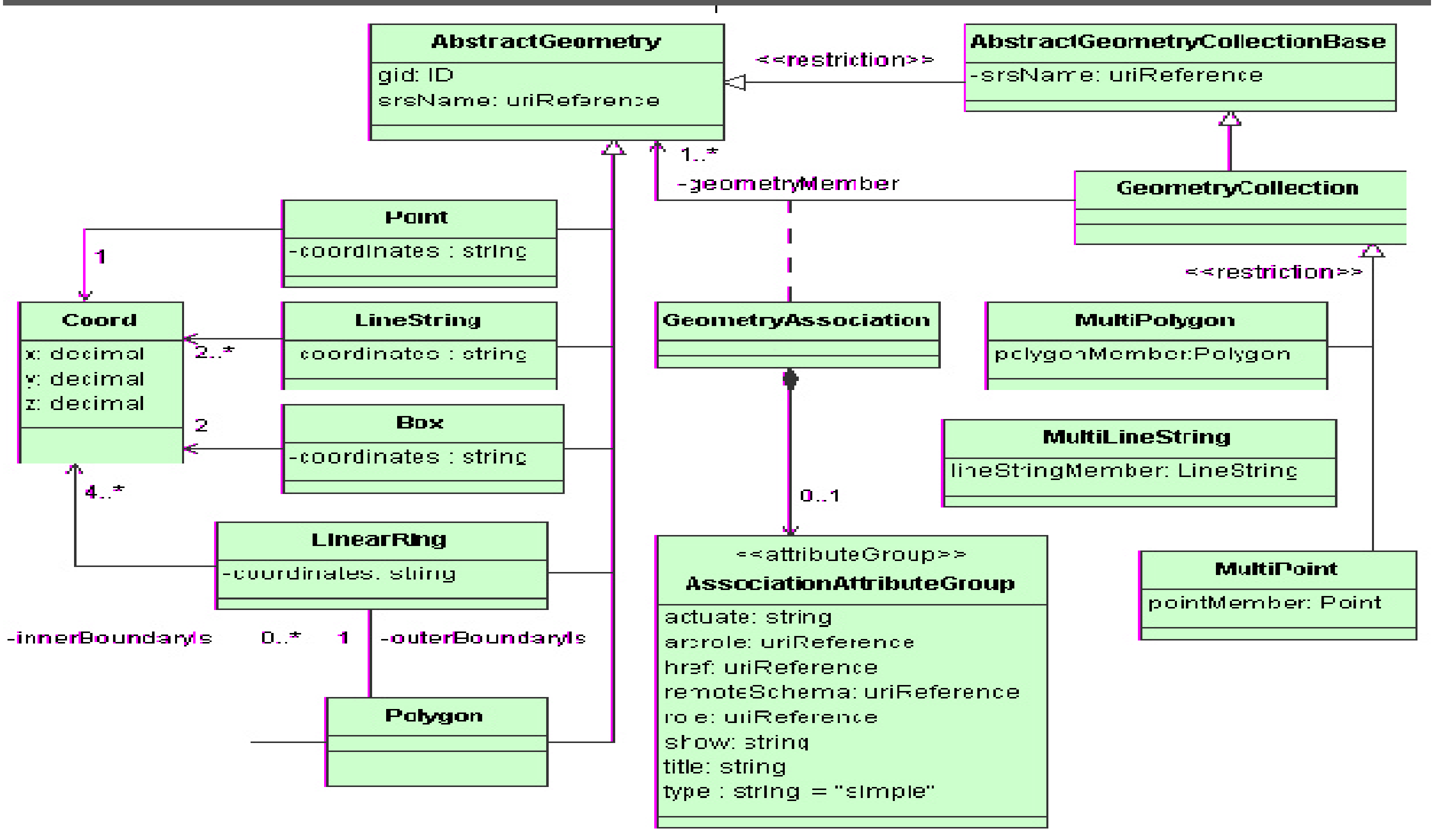

Figure 3.1: UML representation of the Geometry schema

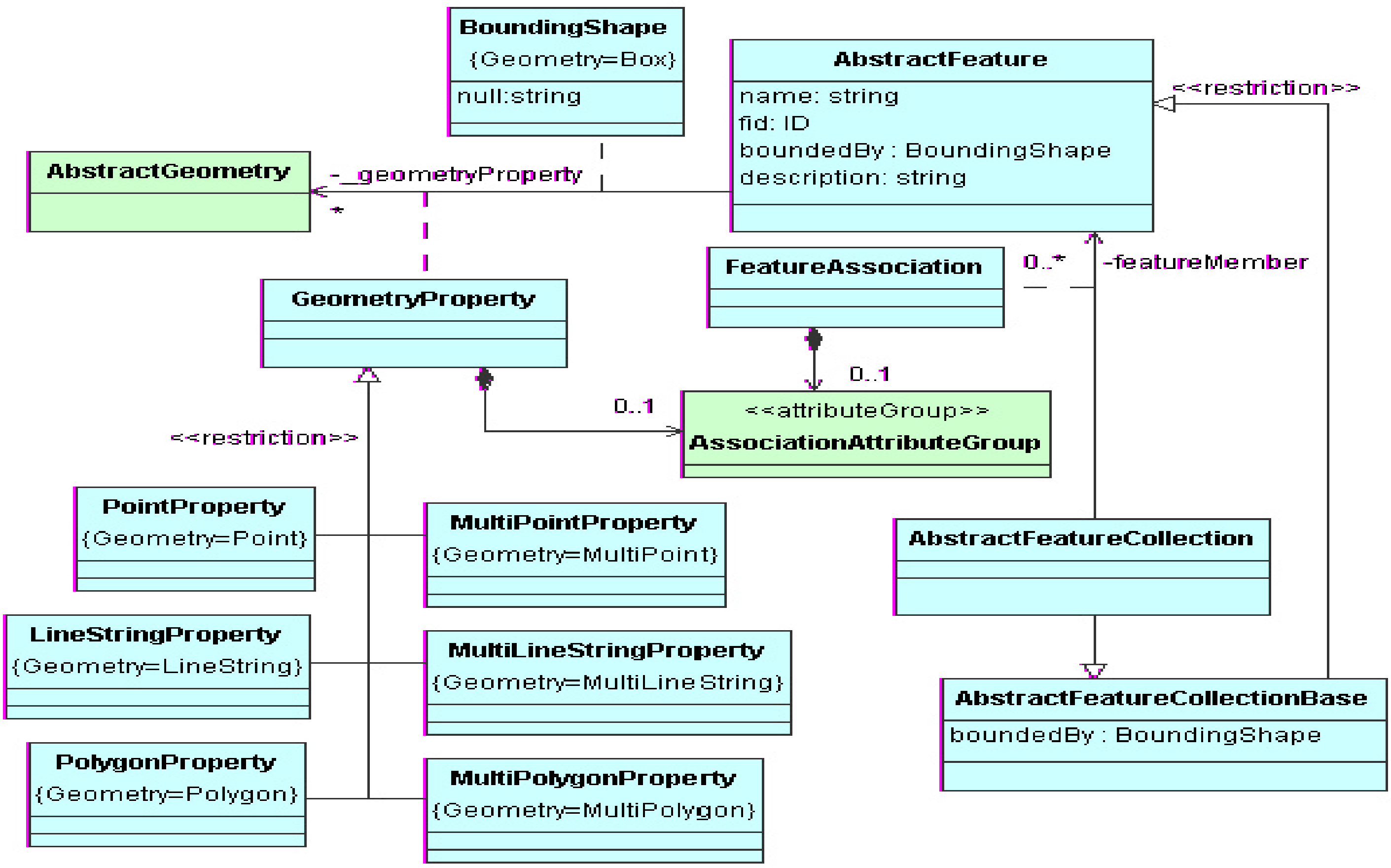

Figure 3.2: UML representation of the Feature schema

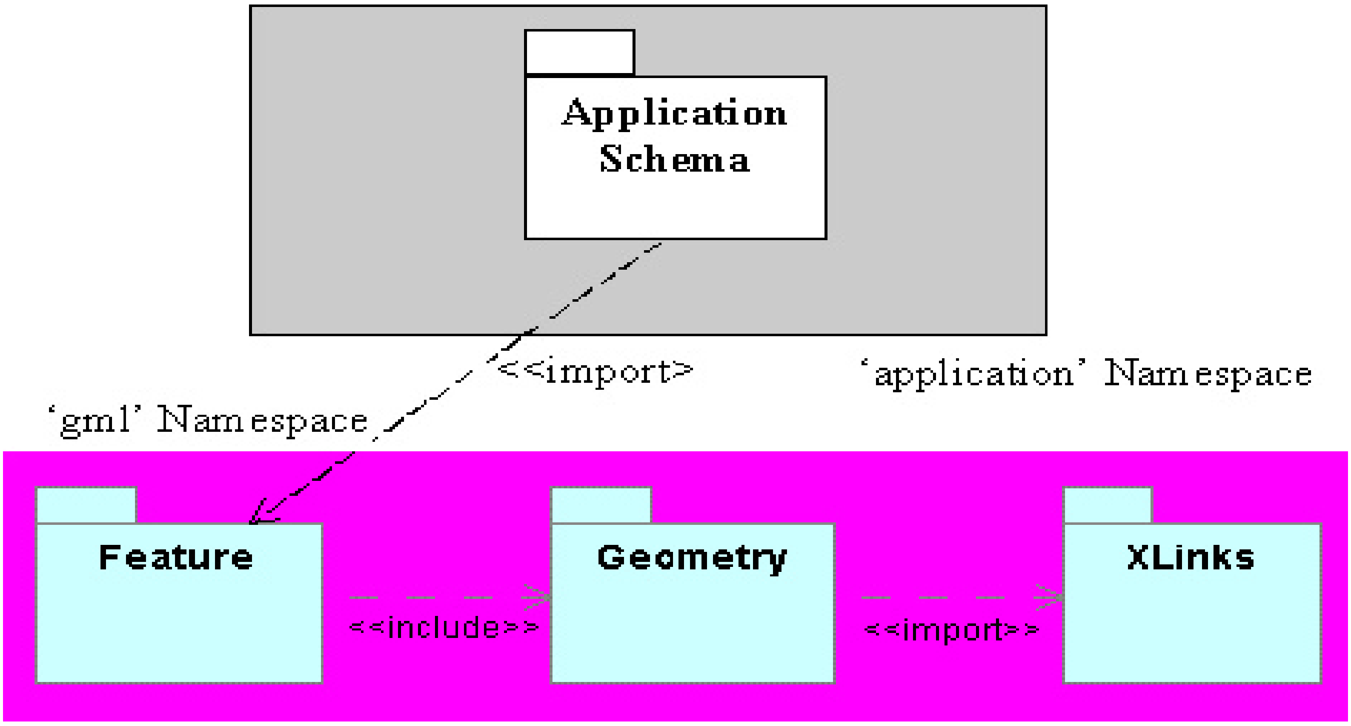

Figure 3.3: Base schemas as UML package

ital representation of the real world can be thought of as a set of features. The state of a feature is defined by a set of properties, where each property can be thought of as a {name, type, value} triple. The number of properties a feature may have, together with their names and types, are determined by its type definition. Geographic features are those with properties that may be geometry-valued. A feature collection is a collection of features that can itself be regarded as a feature; as a consequence a feature collection has a feature type and thus may have distinct properties of its own, in addition to the features it contains.
GML 2.0 defines three base schemas for encoding spatial information :

- The Geometry schema (geometry.xsd) for the description of the Geometry represented with UML in Figure 3.1,
- The Feature schema (features.xsd) for the description of the Features represented in Figure 3.2,
- The Xlink schema (xlinks.xsd) until the Xlink schema will be published by the W3C.

A conformant GML application schema must import the Feature schema as shown in Figure 3.3.

3.2- SVG (Scalable Vector Graphics)

SVG [SVG] is a language for describing two-dimensional graphics in XML [XML10]. SVG allows for three types of graphic objects: vector graphic shapes (e.g., paths consisting of straight lines and curves), images and text. Graphical objects can be grouped, styled, transformed and composited into previously rendered objects. The feature set includes nested transformations, clipping paths, alpha masks, filter effects and template objects. SVG drawings can be interactive and dynamic. Animations can be defined and triggered either declaratively (i.e., by embedding SVG animation elements in SVG content) or via scripting. Sophisticated applications of SVG are possible by use of supplemental scripting language with access to SVG's Document Object Model (DOM), which provides complete access to all elements, attributes and properties. A rich set of event handlers such as onmouseover and onclick can be assigned to any SVG graphical object.
SVG stands for Scalable Vector Graphics :
Scalable : To be scalable means to increase or decrease uniformly. In terms of graphics, scalable means not being limited to a single, fixed, pixel size. On the Web, scalable means that that a particular technology can grow to a large number of files, a large number of users, a wide variety of applications. SVG, being a graphics technology for the Web, is scalable in both senses of the word.
Vector : Vector graphics contain geometric objects such as lines and curves. This gives greater flexibility compared to raster-only formats (such as PNG and JPEG) which have to store information for every pixel of the graphic. Typically, vector formats can also integrate raster images and can combine them with vector information such as clipping paths to produce a

complete illustration; SVG is no exception.

Graphics : Most existing XML grammars represent either textual information, or represent raw data such as financial information. They typically provide only rudimentary graphical capabilities, often less capable than the HTML ‘img’ element. SVG fills a gap in the market by providing a rich, structured description of vector and mixed vector/raster graphics; it can be used standalone, or as an XML namespace with other grammars.

4- Architecture for system integration

Our Project is to propose an architecture based on the “Geographic Markup Language” (GML) to transmit the data from a system to another.

For that, we propose to construct for each system import/export modules which use the GML application schema. The import module will be able to transform GML data into system object (Figure 4.2). The export module that will be able to transform system object into GML data (Figure 4.3).

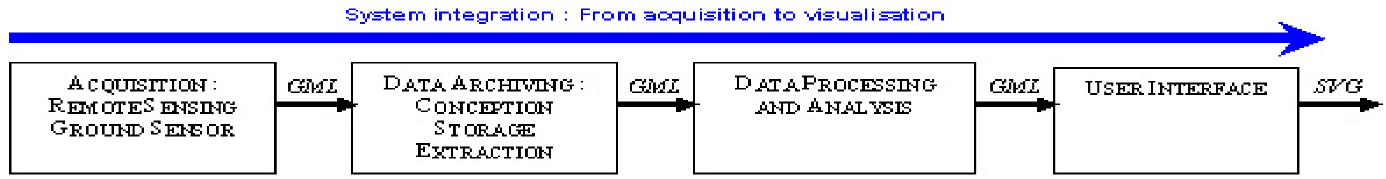

Figure 4.1 : How to realise the data integration

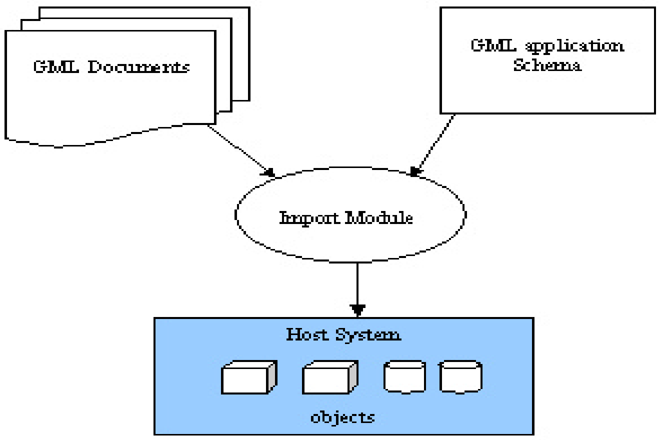

Figure 4.2 : GML data Import

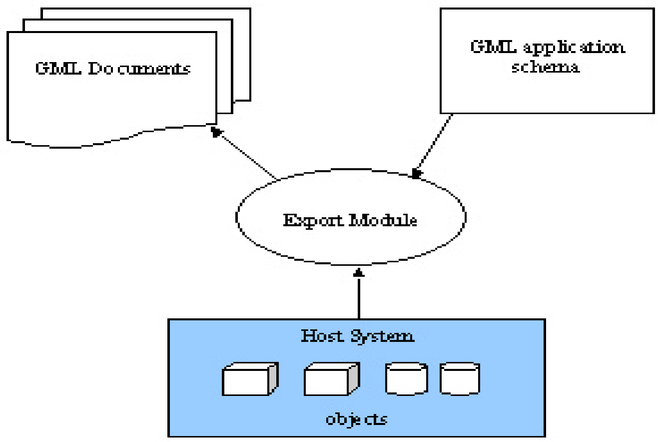

Figure 4.3 : GML data Export

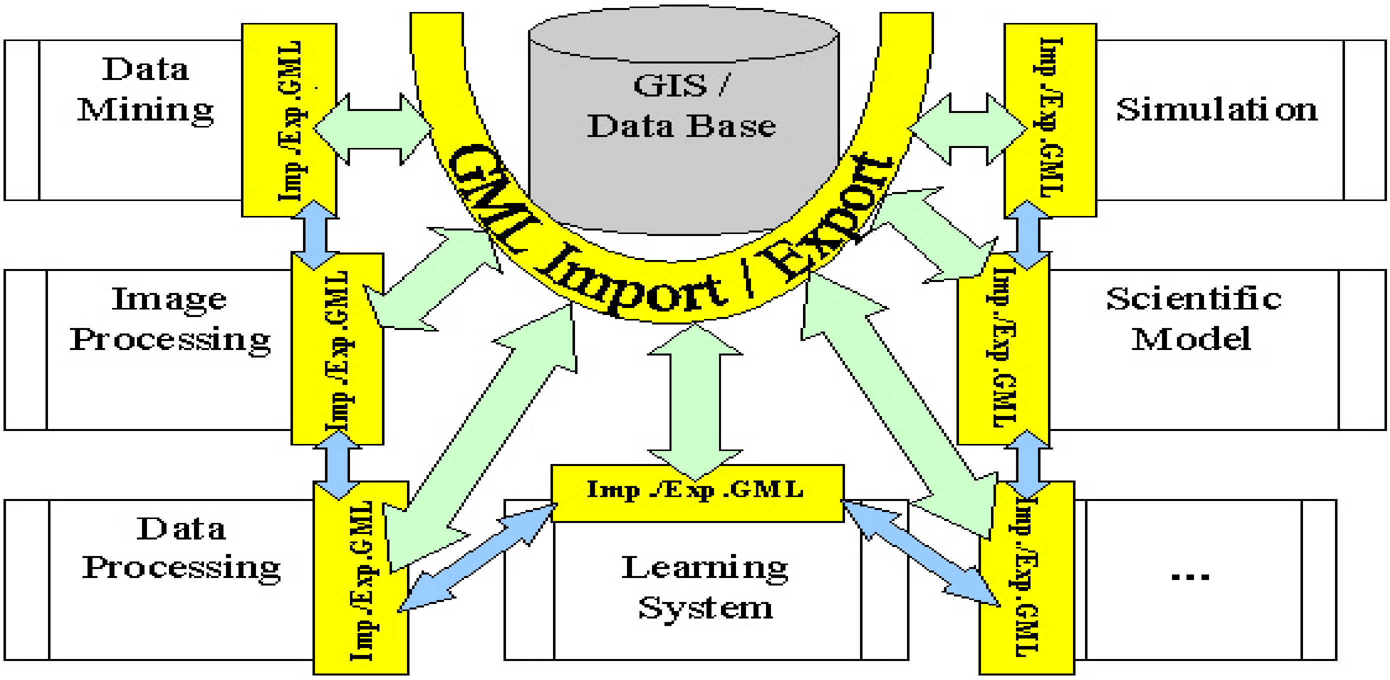

Figure 4.4 : System Interface with GML import / export modules

The OpenGIS consortium specify the functionality of the server side in the Web Feature Server specification (not yet approved). We have to develop the other import/export module in a generic way to be used by many applications and by many external systems. This work has to be done. We suppose that all spatial data could be accessible as GML data. We will focus now on the visualisation process of this GML data with SVG.

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[ISO211] ISO/TC 211, Geographic information/ Geomatics - http://www.statkart.no/isotc211/scope.htm

[OGC] OpenGIS Consortium – http://www.opengis.org – http://www.opengis.net

[OGC99] OpenGIS Abstract Specification - http://www.opengis.org/techno/specs.htm#abstract

[SVG] Scalable Vector Graphics (SVG) 1.0 Specification. W3C Candidate Recommendation, 2 November 2000, < http://www.w3.org/TR/2000/CR-SVG-20001102/index.html >

[WFS] Web Feature Server : OpenGIS Project Document 01-023, Editor: Panagiotis A. Vretanos (CubeWerx Inc.) issued by the WWW Mapping SIG - http://www.opengis.org/techno/discussions/01-023.pdf

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[XMLSchema-1] XML Schema Part 1: Structures. W3C Candidate Recommendation (24 October 2000). < http://www.w3.org/TR/xmlschema-1 >

[XMLSchema-2] XML Schema Part 2: Datatypes. W3C Candidate Recommendation (24 October 2000). < http://www.w3.org/TR/xmlschema-2 >

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Quarantine Surveillance For Fruit Flies

Asesela Wata, Ministry of Agriculture

Introduction

Fruit flies are a national concern because they cause a lot of damage to fruits and vegetables and they also hinder international trade of fresh fruits and vegetables. To monitor the fruit fly population in Fiji, a network of fruit fly traps have been established around the country. These traps are on the islands of Viti Levu, Vanua Levu, Taveuni, Kadavu, Ovalau, Beqa, Moala, Yasawa Group and Rotuma. To supplement information generated from these fruit fly traps, regular sampling and surveying of fruits are also carried out. These fruit fly trapping and host fruit survey are the basis of the national quarantine surveillance system for fruit flies. This is a requirement of importing countries for any form of trade in fresh fruit and vegetables.

The fruit fly trapping system is also designed to detect as early as possible, the incursion of an exotic fruit fly species. This will then help eradication attempts or other actions. Traps are therefore concentrated in urban areas, farms (of fruit/vegetable production), near ports of entry and in areas of tourism activity.

Recently, the GIS unit of the Land Resources, Planning and Development department assisted the fruit fly research team in the production of maps showing the distribution of fruit fly trap sites over the various islands. These maps give the viewer an idea of how much cover fruit fly traps have of Fiji's ports of entry, urban centers and production sites.

A modified version of the Steiner fruit fly trap is used in Fiji and the most widely used chemical attractants are methyl eugenol (usually abbreviated **ME**) and 4 – (pacetoxyphenyl) – 2 butanone (usually abbreviated **CUE**). At some sites, a third one called trimedlure (**TRIMED**) is also used. These attractants are specific to fruit flies only.

Through fruit fly trapping and fruit host surveys, it is established that there are 7 species of fruit flies in Fiji. These are:

Bactrocera passiflorae (Frogatt) attracted to CUE
B. passiflorae light form (found only in Lau and Nadarivatu) attracted to CUE
B. xanthodes (Broun) attracted to ME
B. distincta (Malloch) attracted to CUE
B. gnetum Drew and Hancock no response to either
B. obscura (Malloch) (found only in Rotuma) attracted to CUE
B. kirki (Froggatt (found only in Rotuma) attracted to CUE

Status of GIS in Niue

The Research Division, the Extension Division and the Quarantine section of the Ministry of Agriculture, Sugar & Land Resettlement, jointly carries out the clearance of fruit fly traps. These are usually cleared every month and re-baiting every three months. The plant protection staff of the Research Division conducts the host fruit survey.

Methodology

The initial data format was in Excel spreadsheet with all the locality names. We had to again confirm on some of the names given before dotted down a point indicating the position. We had to use the river system

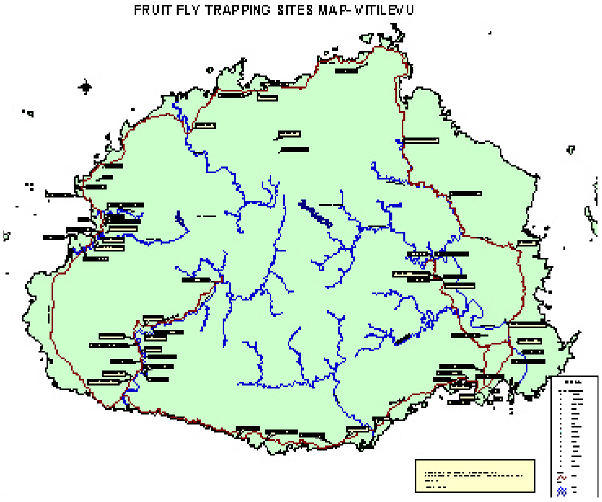

Figure 1: *This map shows the Fruit Fly trapping sites around Viti Levu.*

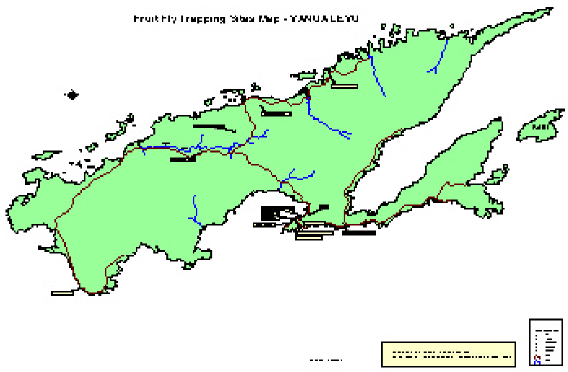

Figure 2: *This map shows the Fruit Fly trapping sites around Vanua Levu.*

for orientation.

We had the outline of the two main islands already in Mapinfo. Since, we want to use ArcView, we then export outline boundary from MapInfo into ArcView. The general layout of the map is done in ArcView.

We had suggested to the Research Section for the inclusion of the Database linked to each point or position.

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STATUS OF GEOGRAPHICAL INFORMATION SYSTEMS IN NIUE ISLAND

Coral Pasisi, Environmental Planner

The Environmental Planning division in the department of Justice Lands & Survey, houses the government's GIS. Over the past 4 years the GIS has been built upon as a tool for government policy towards physical planning and environmental protection.

Over 200 layers of information gathered from the communities in Niue as well as documented reports on the status of various resources, and future development aspirations have molded a database that will be built on and maintained by government. Further to maintaining the GIS, the department is actively promoting GIS as a tool for resource management in other government departments as well as community based initiatives e.g. the use of GIS in Cultural Heritage parks and marine reserves. Sensitive information such as tapu areas and burial grounds may be mapped for local communities and kept as classified information for that village only. This will ensure in the long term that knowledge is not lost for future generations, however still limits the access to inquisitive tourists or other public.

Maintenance of GIS is one of the most difficult tasks in Niue due to the high turn over of staff, and the frequent break down of equipment. As a result the department is now seeking funds to upgrade the GIS as well as secure its long-term sustainable management. Included in this is the proposal for image analysis software for some remote sensing capabilities, the networking of the entire department, with increased capacity hardware for higher processing speed of large images.

Training more staff is central to this initiative, both within the department and within the wider public service. It is hoped to also involve interested members of the public in the use of GIS as a possible tool for local resource management and future rural planning in their respective villages and communities.

In July this year a delegation of 14 US Military and civilians came to Niue as part of a Disaster management initiative. The mission included the capture of data for the compilation of a GIS for Disaster management efforts on the Island. This is currently being put together with a pan sharpened IKONOS image of Niue. It is hoped that the end product will be a comprehensive mapping and database storage system that will allow for better Disaster preparedness and mitigation.

The Forestry unit of the Department of Agriculture,

A New Hight-Resolution Satellite

Forestry and Fisheries also have Mapinfo set up with a few layers used to manage their forestry plots. The unit is now hoping to take a more active role in the determination of vegetation cover change of the last 20 years. Landcare New Zealand is involved with the Forestry Unit in the acquisition of satellite data for remote sensing of land cover vegetation. This will help quantify many aspects of land use, including the rate of deforestation, that can in turn be a measure of biodiversity loss versus agricultural gain.

The prospect of improved hardware and more training in GIS is a positive step in the continued quality and integrity of data captured and built upon. The government is committed to ensuring that GIS becomes more widely used, and is available also to the public for resource management and planning.

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QuickBird2, A New Hight-Resolution Satellite

Wolf Forstreuter, SOPAC

The QuickBird satellite was successfully launched on October 18, from Vandenberg Airforce base, California, by a Delta II rocket (see Figure 1). Shortly after the launch of the QuickBird, a DigitalGlobe ground station received a downlink signal confirming that the satellite successfully separated from the launch vehicle and had automatically initialised the onboard processors. After an on-orbit calibration and commissioning period of about 90 days, QuickBird will begin acquiring image data. However, the first images for the public are expected only in February 2002.

Figure 1:Delta II Rocket

DigitalGlobe is an imagery and information company located in Longmont, Colorado. This private company will handle the data distribution.

Built by Ball Aerospace, the QuickBird spacecraft (see Figure 2) was originally designed to provide one-meter resolution from a 600 km orbit. But DigitalGlobe decided to lower the altitude to 450 km to improve the resolution. QuickBird's colour imagery was improved from 4-metres to 2.44-metres with the orbit change. The satellite has a 98 degree sun-synchronous orbit similar to Landsat. One orbit takes 93.4 minutes, but the revisit varies with latitude; at 40 degrees north latitude, it averages 3.5 days at up to 30 degrees off-nadir angle (corresponding to 0.73 meter resolution). There is a difference in resolution between nadir and off nadir. 61-centimeter at nadir and 73-centimeter at 30 degrees off-nadir for panchromatic image data and roughly 2.5 meter at nadir and 2.9 meter at 30 degrees off-nadir for multispectral images. The standard pan and multi resolutions for standard processed products will be 70-centimeter and 3.0-meter respectively. Customers who purchase unprocessed data can get imaging collection resolutions of up to 61-centimeter.

Figure 2: *QuickBird2*

The swath width will be 16.5 kilometer at nadir, or 17-20 kilometers under typical operations and within roughly 4 seconds the sensor captures a 17km x 17km image. It is also possible to collect in-orbit stereo pairs.

There are some US regulations that will apply for data delivery. DigitalGlobe cannot deliver imagery at less than .82m resolution within 24 hrs after acquisition, unless approved by the US Govt. Imagery products will be made available in industry-standard formats, such as GeoTIFF, for use in a broad range of mapping, image processing, and geographic information system (GIS) software packages. In addition, DigitalGlobe will publish the characteristics of the QuickBird sensor model, initially to commercial software vendors, to allow full support of stereo imagery for photogrammetric processing.

It is important for Pacific Island Countries that QuickBird has onboard tape facilities to store image data as the Pacific is outside of the footprint of any ground receiving station. SOPAC is currently establishing a link to DigitalGlobe and will inform the potential users via GIS-PacNet.

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GIS in Samoa: after a slow start GIS begins to take off

James Atherton, GIS Consultant
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Introduction

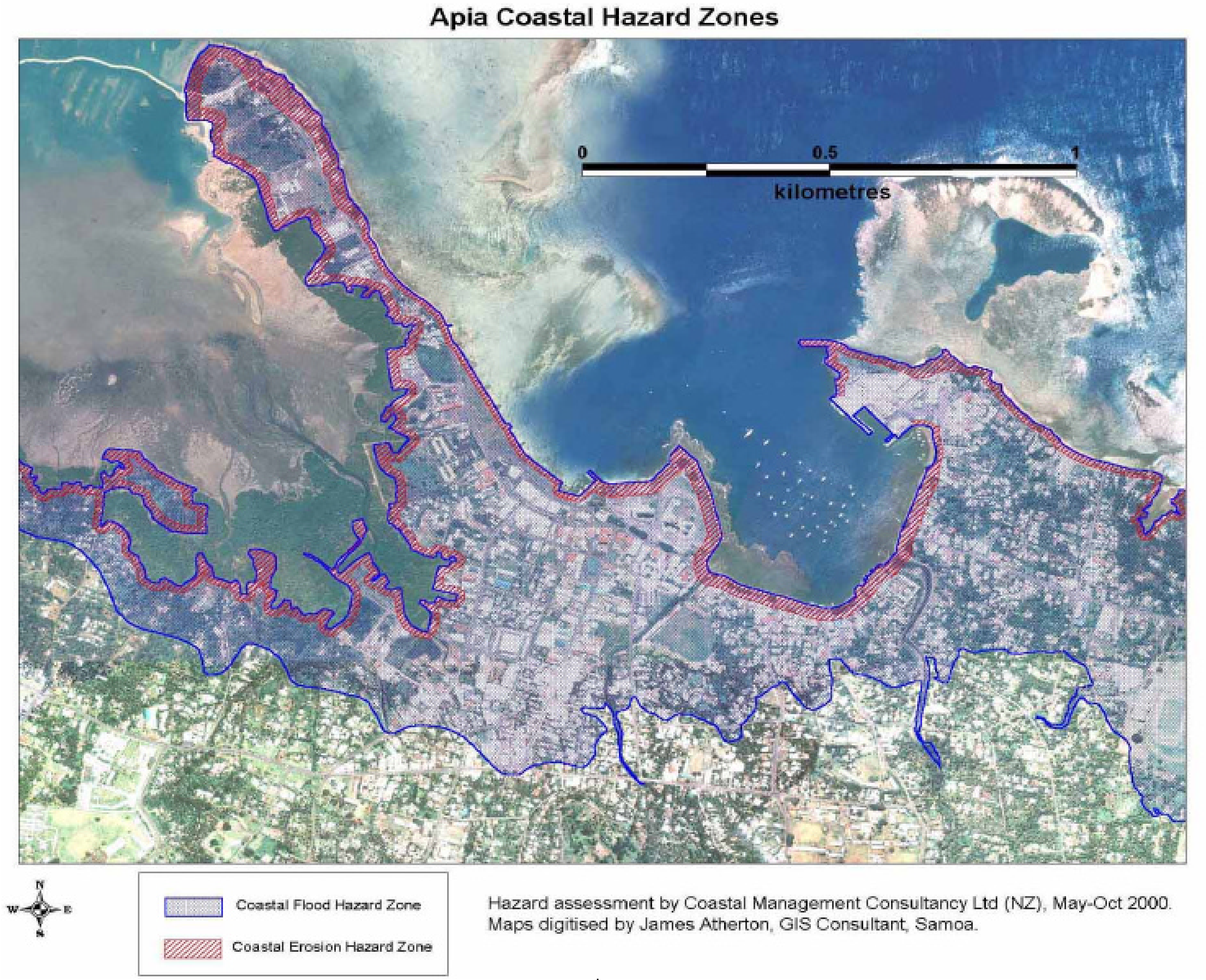
GIS is a relatively new technology in Samoa. Although the first national GIS database was established more than 10 years ago (in 1990), it was not until the late 1990s that GIS came to be more widely used in Samoa. Now, GIS projects are underway in four government departments, and a new GIS project is planned in one more department. The benefits of GIS for asset management, environmental planning, spatial analysis and cartographic output are at last being realised by both the government and the private sector.

Major Projects Currently Underway

A number of GIS activities are currently being undertaken in Samoa. Projects are being conducted, or have recently been completed, in the following Government departments or agencies: Department of Lands, Surveys and Environment, Department of Statistics, Public Works Department and Samoa Water Authority.

Department of Lands, Surveys and Environment (DLSE)

Samoa's first National GIS database was developed



in 1990 with financial assistance from the Asian Development Bank through a joint project between UNDP, DLSE and the Ministry of Agriculture Forestry, Fisheries and Meteorology (MAFFM) on behalf of the Government of Samoa. Technical assistance and advice was provided by ANZDEC consulting of Auckland, in association with the Division of Land and Soil Science, Department of Scientific and Industrial Research (DSIR) New Zealand. The project was known as the Natural Resource Inventory for Samoa. The ArcInfo based system provided digital maps created at 1:50,000 scale of roads, rivers, elevation, land capability, land suitability, land tenure, land use and soils. Unfortunately, due to corruption of datasets and damage to computer equipment from a cyclone, the database was hardly used.

In 1999 the DLSE through an adaptable program with IDA/World Bank received digital ortho-photographic data of Samoa at 1:5,000 scale along the coastal hinterland and 1:50,000 scale photography for the whole country. New GIS data of buildings, roads, rivers, vegetation cover and 2m contour lines were generated at 1:50,000 scale. GIS data at 1:10,000 scale are expected to be received soon and should include all features larger than 4 m x 4 m in area. Airesearch Mapping, an Australian mapping firm, did the aerial flight and produced the GIS formats and the orthophotos. These base data are now being used for a variety of projects including the development of digital coastal hazard zone maps for the whole 573km coastline of Samoa. The coastal hazards database includes maps of areas prone to coastal erosion, landslip and flooding, along with field data from 276 survey stations.

The maps are being used to plan coastal protection works and to manage new coastal infrastructures, such as roads and public buildings.

A sample GIS map from the coastal hazards database (source DLSE 2000) is shown below.

Department of Statistics

A GIS is currently under development by the Samoa Department of Statistics (see GIS/RS News Issue 1/2001). The project involves the digitisation of 158 census map sheets including 878 enumeration areas and approximately 30,000 households. As with other GIS projects in Samoa, aerial photography from DLSE is being used as map backdrops. The project has a number of benefits: it will ease the correction/update of census maps, improve flexibility to plot census maps at a variety of scales, facilitate census planning, improve map presentation options and establish a spatial data exploration, analysis and output capability for census data. The work is being performed using MapInfo software and is expected to be completed in mid 2002, hopefully in time to map the findings of the latest national population census (November 2001).

Public Works Department (PWD)

PWD are developing the Samoa Asset Management System (SAMS) for road assets especially roads, bridges, seawalls and buildings. The role of this system is to provide an accessible inventory of PWD assets in order to provide a tool for forward planning of maintenance and upgrade works.

The SAMS consists of a central database developed in Microsoft Access to hold the attribute information, and this interfaces with a MapInfo based GIS application. All assets have been geo-coded using a GPS and given a unique location reference point. Attribute information, along with digital photographs of each asset, have been entered into the database.

Samoa Water Authority (SWA)

The SWA have developed a GIS of water assets for the Apia urban area in ArcView. Pipes, hydrants and valves have all been digitised along with attribute information such as pipe material, diameter and roughness. Digital aerial photography supplied by the DLSE, is used as backdrop images. Pipe2000, a hydraulic modelling software package, is being used to model demand scenarios, taking into account forecasted population growth in the Apia urban area. These forecasts will be used to determine necessary network modifications.

Future Projects

The Forestry Division (FD), of the Department of Agriculture, Forestry and Fisheries are hoping to update the national forest inventory in 2002. FD plan to use interpretation of digital aerial photography, coupled with field surveys, to map the indigenous forest cover. Digital forest cover maps will be used to ascertain the rate and trend of deforestation since the previous forest cover maps (1991) and to provide an assessment of remaining merchantable forest resources. Such information is critically important for the sustainable management of Samoa's threatened forest resources.

Conclusion

After a slow start GIS has recently undergone rapid development in Samoa. The future for GIS development in Samoa certainly looks bright now that government and the private sector realize the need for a tool that can bring relevant sectors and disciplines to discuss and agree on issues of common interest. The role of good data is commonly recognised as a key one for good plans and actions. This belief has been strengthened through the use of GIS technology, which assembles and presents spatial data in such a way that catalyses understanding, response and decision making at all levels. It is a presentation of information that welcomes participation of communities, the government and the general public and thus promotes an ethic for partnership for all development and conservation activities.

Samoa, with the growing pressure for sustainable development and environmental conservation, is moving in the right direction through the deployment of GIS to support actions and plans on the management of their fragile and limited resources.

The overwhelming growth in technology requires a consistent approach to support the institutional capacity of the country to sustain in parallel the use of GIS technology and the relevant applications it offers.

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Workshop on Remote Sensing Resources For Marine Management

Silika Tuivanuavou, FLIS

Workshop Overview

Remote sensing of the physical and biological properties of the oceans and the coastal zones provides information that enables effective approaches for the monitoring and management of extensive oceanic regions at relatively low cost. The information from current satellite systems is now quantitative, widely accessible and amenable to incorporation into regional database systems and use over time to define baseline conditions that incorporate statistics on seasonal and interannual variability. A database, in principle, may be equipped with decision support systems tuned to the users' requirements and applied to identifying changes in the marine environment that are significant in a management context. Alternatively, the database may serve as input to a numerical ecological model that includes both ocean dynamics and biogeochemical parameterisation. The implementation of such systems requires a certain level of understanding of the data and information and of the oceanography of the region being monitored or studied.

The Workshop was designed primarily to stimulate participants' interests in formulating potential opportunities in their own region to which remotely sensed information for regional management may be applicable. It would serve as an introduction to the data sources, the information content, the water quality products and their interpretation. It was intended to discuss a range of applications and case studies to illustrate how the information may be utilised. A participant-led session was held on two afternoons to initiate a discussion of issues of regional importance where these technologies and methods may be applied. Future Workshops will extend regional capacity building by examining aspects of the science, information system requirements and their implementation for addressing particular applications in marine management.

Figure 1: *Picture of the participants to the Remote Sensing workshop*

Goals

The goals of the workshop were that participants would:

- Gain an appreciation of the accessible sources of remotely sensed data that are available to managers of the marine environment,
- Achieve an understanding of the relationship of remotely-sensed information to the physical and biogeochemical properties of the marine environment,
- Develop an appreciation of the approaches applied to these data sources to convert them into a spatial-temporal information database for application to management of the marine environment, and
- Gain experience in the formulation of marine

management strategies through analysing case studies and formulating ideas for new regional strategies.

Objectives

The Workshop planned to:

- Identify remotely sensed data sources, their quality and utility for application to the marine environment.
- Relate the spatial and temporal variability in ocean observations to oceanographic and biogeochemical processes.
- Review selected case studies that provide insights into the interpretation of the remotely sensed ocean observations and their application to marine management.
- Study regional scenarios and priorities in the management of marine resources and to formulate appropriate support strategies using remotely sensed information.

Workshop Design

The Workshop included 6 experienced lecturing staff and approximately 15-18 participants who have interests in gaining insights into remote sensing information and its potential for regional application. The Workshop was conducted over three days.

Figure 2: One of the very studious sessions.

The Workshop included extended discussion of relevant aspects of remote sensing information, its interpretation, limitations and the utility of temporal-spatial data in assessing the mean condition and variability on a marine environment. An appreciation of the use of such data to support marine management was illustrated by case studies and lead to a focus on regional priorities and the formulation and evaluation of potential strategies to address these needs. Participants were encouraged to provide regional data sets (biological/ecological, nutrient, oceanographic, meteorological) for use in Workshop discussion sessions. However, none of the participants had any of these datasets mainly because we had no access to these datasets nor did they exist at all.

A Workshop session was directed at illustrating the processing of raw satellite data to products for marine management, which was not very successful in my view due to the very limited time for the session and the difference in software used.

The important role of undertaking in situ measurements, the essential wet lab instrumentation suite for water sample analyses and the relation of these properties to the remotely sensed products was discussed at length with case studies.

A key theme throughout the Workshop was the development of an awareness of relevant international ocean observing programs and the importance of standards and protocols for data and information exchange.

Workshop Sponsors

The International Oceanographic Commission (IOC), an agency of UNESCO and the Curtin University of Technology were sponsors of the workshop. The IOC was founded on the recognition that the oceans (covering some 70% of the Earths surface) exert a profound influence on mankind and all forms of life on the planet. The IOC's aim is to promote marine scientific investigations and related ocean services, with a view to learning more about the nature and resource of the oceans.

The workshop was held in the Institute of Research and Development Center (IRD) in Noumea, New Caledonia from the 25th to the 27th of September 2001.

Outcome

The topics covered at the workshop include:

1. Remote Sensing applications, their accuracy, the products acquired, the interpretation, new sensors, future products and the bio-indicators.
2. The Regional agency programs and the regional use of the RS data.
3. The issues discussed were factors affecting:

- Fisheries
- Mining
- Coral reefs mapping and lack of Scientific expertise to undertake more meaningful survey, which I brought up after going through a paper prepared by 2 staff of the World Wide Fund For Nature (WWF) office in Suva.
- Phytoplankton
- Baseline studies

We had a chance to view and work on some Remote Sensing data downloaded from their respective sites using Red Hat Linux 6.1.

Recommendations:

1. Further courses are required on Ocean Color Interpretation and algorithms to be able to make better sense and use of the RS data and to enable better Marine Resource Management.
2. More workshops of this nature need to be run and the focus to be on the projects done in the region.
3. More time should be given for participant's discussion of issues raised from their respective countries.
4. The involvement of staff dealing with Marine Conservation and Fisheries would be a great advantage to them.

Brief Overviews of Kiribati Current GIS and Related Activities

Tebutonga Ereata, Land Management Division

Introduction

Kiribati is a country primarily of water 3.5 million square kilometres but land area is 750 square kilometres for whole country. There are 33 islands all together with only 21 inhabited. Kiritimati (Christmas) island covers 360square kilometres and it is located 3500 east from Tarawa the capital. All the islands are coral, low-lying atolls with the exception of Banaba which is a raised island some 80m above sea level. The other islands rise barely 6m above sea level.

There are 3 main groups of islands, Gilbert group, Phoenix and the Line Islands. The national population was 88000.

Topographical Base maps

Topographical maps for most islands in Kiribati are available based on aerial photography done in 1968 and 1969 by DOS UK and in 1984 by the Australian Defence Force. In 1998 Tarawa alone was flown by Schelenker mapping organisation Australia. The recent photography has produced the basis for the new spatial data for Tarawa. The image data was geo-referenced and has formed the image backdrop and layers of the GIS.

The GIS software installed was MapInfo and based on the images captured from the aerial photography the following layers of the GIS were established:

- Coastline
- Buildings
- Contour lines
- Roads
- Sea walls
- Vegetation
- Reef areas
- Lagoon areas
- Misclaneaous topography

Additional cadastral data captured by survey methods were input into the new GIS. These created additional layers of land ownership boundaries.

Kiribati Land Information System

With the establishment of the GIS and the additional cadastral information input the Kiribati land Information System (KLIS) was established. Fortunately through AusAid funding all filing, title registration and manual registry systems were computerised and made digital. These were text data created in MS Access that were linked by common identifiers to the map data in the GIS. Basically the common identifier common to both databases were notably the land plot numbers. It was by interacting these texts and map databases that the Kiribati Land Information system was formed. A Query program was then formulated by DH. Hebblethwaite Data Visual Pty Ltd Australia which has virtually served all purposes for extracting land information for general public and other Government bodies enquiries.

GIS Programs

It was not until the beginning of this year that this Division began to initiate and introduce the established GIS to other potential Government and Private organisation users. A GIS User Group was established and luckily a significant number of mostly Government organisations expressed keen interest. Under this initiative this Division began to share out the digital data to other users. Most of the Departments were beginners however through the assistance of our Cartographer these Departments are now set and slowly they are beginning to master the basics of the software MapInfo. Unfortunately due to financial constraints the GIS in some other Departments is still yet to be set up.

The GIS User Group now comprises the following Government Departments:

- Land Management Division
- Agriculture Division
- Fisheries Division
- Mineral Unit of Ministry of Natural Resources
- Ministry of Environment
- Ministry of Health
- Public Works

- Kiribati Telecommunications
- Kiribati Housing

Currently there has been work done with the assistance of SOPAC to introduce GPS to form the basis for accurate positioning which would strengthen the current GIS for all users. This is still in the pipeline and funding for the establishment of the GPS base station is currently being pursued.

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IKONOS Multispectral for Vegetation Monitoring in Kosrae, FSM

Blair Charley, Ciorsdan Daws
DRC, Kosrae, FSM

Introduction

AusAID has funded the purchase of IKONOS high-resolution multispectral satellite data and four weeks of GIS training for Kosrae, to enhance the GIS activities of the active Kosrae GIS user group. The training was carried out by SOPAC at DRC (Development Review Commission). A three-day workshop for the GIS user group updated the information necessary to utilise the satellite image data. SOPAC also brought a GPS rover, a GPS base station and remote sensing software to Kosrae in order to convert the satellite image to GIS image backdrops, enabling different GIS users in Kosrae to analyse them in a MapInfo environment.

Establishing the GPS Base Station

The idea was to be independent from any local grid and subsequent transformation to world known grid systems. Therefore it was necessary to average the position of the base station for several days. With the friendly help via e-mail from Reece Gardner, Trimble Navigation New Zealand, it was possible to use the GPSurvey V2.35a software instead of Pathfinder office. This allowed utilising all the raw measurements of the installed 4600 SL antenna and receiver (see Figure 1). Pathfinder Office would only use the CA code position recorded every 5 seconds.

Figure 1: *GPS Antenna*

Rectifying the IKONOS Image

After averaging the base station, the main roads in Kosrae were surveyed by driving along the roads while one of the team (the "power survey team" was built by members of Survey and Mapping and DRC, see Figure 2) held the GPS rover on the back of the truck. Surprisingly there was low satellite receiving in Kosrae and the team had to wait several times before it was possible to continue driving. However, within two days all main roads were mapped, which provided sufficient reference to check the geographic reference of the geocoded satellite image.

Figure 2: *The «Power Survey Team»*

When the road system was displayed on top of the IKONOS image it was visible that the IKONOS image was 40m off. It appeared to be a linear shift and the geometric correction was performed as polynomial rectification of first degree. To use an affine transformation also had a different reason: it was impossible to identify Ground Control Points (GCPs) in the south west part of the island, which would certainly effect a rubbersheet transformation, but would also influence the output of a second degree polynomial rectification. The result of the geometric correction was convincing, all of the roads derived from GPS survey fit exactly on top of the image.

Many departments can now use the resulting GIS image backdrop. All government institutions have the same reference, which is the key for exchange of quantitative information.

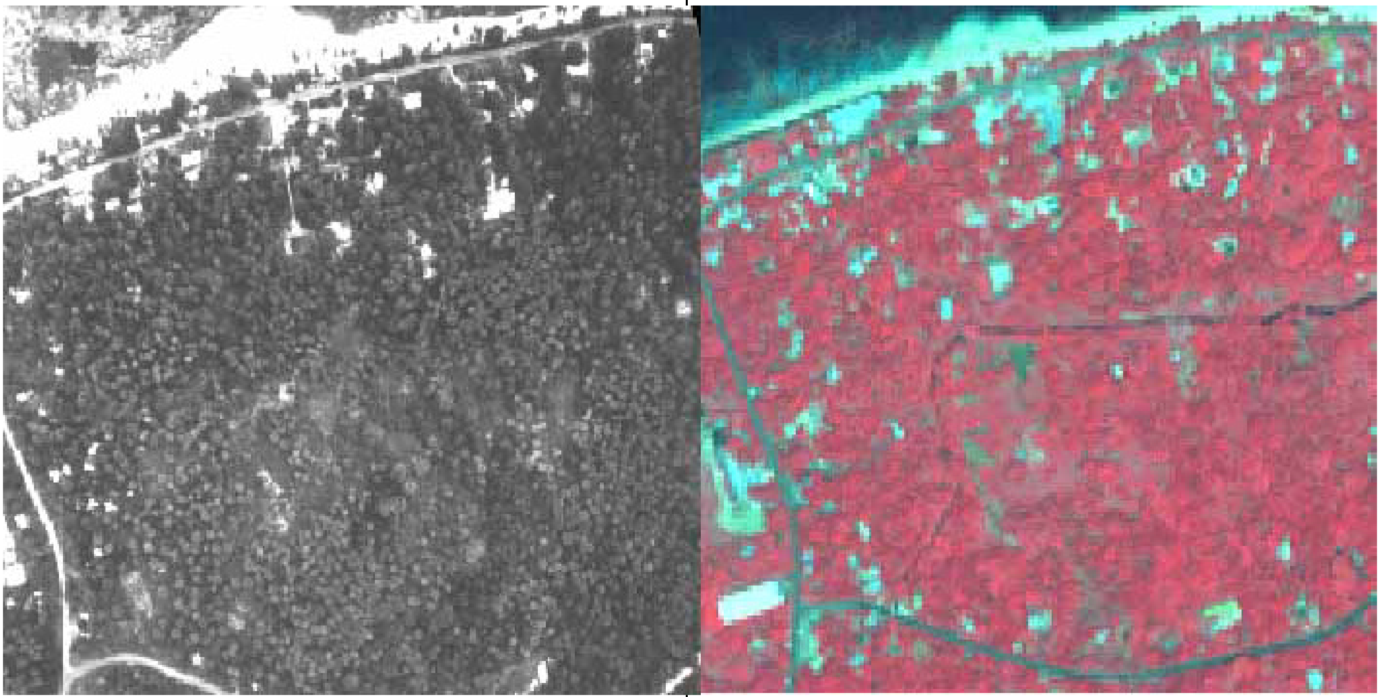

Figure 3: *This image shows the only area where a change in the coastline had been identified.*

Vegetation Change Detection

The IKONOS image not only provides a basis for vegetation mapping showing the situation in the year 2000 when the image was recorded, but it also provides a reference which can be utilised to rectify historical aerial photographs after converting them to digital images through scanning. In the SOPAC archives photographs from 1976 and 1985 were found and scanned. ERDAS rubbersheet module enables the transformation of the central perspective of these photos to a world-recognised grid. Vegetation features can be used as GCPs not be identifiable on any map, but clearly visible in both the satellite image and aerial photographs.

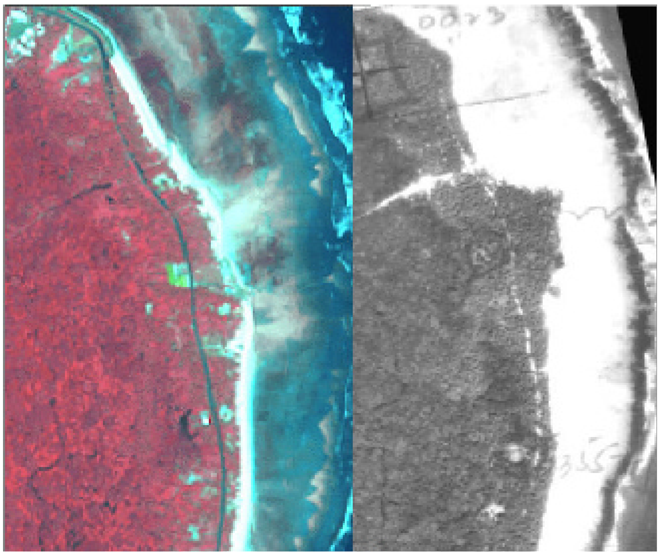

Figure 4: *This image is a comparison of the rectified aerial photograph recorded 1976 with the IKONOS image, which shows that in the north east of Kosrae destruction of coastal vegetation took place.*

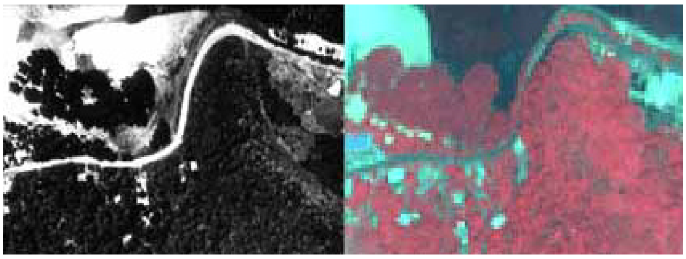

Figure 5: *The on-screen comparison of the aerial photograph recorded 1983 with the IKONOS image shows that the mangroves got denser at this area in the north of Kosrae.*

Using ERDAS software it is possible to drive a cursor simultaneously in both pictures, the satellite image and the rectified aerial photograph. Changes of coastline or missing vegetation can be detected visually. Surprisingly there were not many major changes in the coastline, the only one identified is displayed in *Figure 3*. Some disappearance of vegetation in the north east of the island is shown in *Figure 4*. In the north a tremendous increase of housing is noticeable (see *Figure 5*), however, this obviously does not result in major changes to the coastline. An interesting fact was that mangroves increased in some areas (see *Figure 5*). This is an observation also recorded by Dick Watling in Fiji, obviously resulting from increased sediments of the river water, which is often an effect of erosion upstream.

Recommendation

The IKONOS image provided for the first time a mapping basis for this small island country. It also enabled the analysis of vegetation change using historical aerial photographs. In Kosrae the remote sensing software and GPS base station were temporarily installed by SOPAC.
Future Phases of the Kosrae State Information System should consider the purchase of this software, and an A3 size scanner, to make Kosrae independent from SOPAC for these standard activities. Furthermore, such a set-up could be installed in other Pacific Island Countries to monitor vegetation change. This could be used as an education tool to avoid excessive deforestation, which would result in coastal erosion.

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The open source software movement and its potential in implementing Spatial Data Infrastructures

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Authors Biographies

1) John Reid (jgreid@uow.edu.au) is the Technical Officer responsible for administration of the local computer systems and server infrastructure for the School of Geosciences at the University of Wollongong. Previous experience working with spatial information and databases includes several years as a technical assistant in the oil exploration industry. He has no formal academic qualifications.
2) Franck Martin (franck@sopac.org) is the Network and Database Developer for the South Pacific Applied Geoscience Commission (SOPAC) in Fiji. He has run several GIS/RS workshops in Pacific Island Countries as well as developed several custom made GIS using MapInfo. He is participating in workshops to advise on information and communication technologies for the Pacific Islands. Lately, he is working on setting up a system for metadata exchange within the Pacific Islands
.

Abstract

This paper will examine some of the potential benefits and drawbacks of open-source software, and how this could be used in implementing Spatial Data Infrastructures (SDIs), drawing on the authors' experiences with the FMaps project and other open source projects related to spatial information systems.

The open-source movement brings a new philosophy in the way software is made. It is not only about GNU/Linux nor about having access to the source code, it is about giving the right to anybody to modify the software in any way they like (freedom). This software can be used as an extension to proprietary software, with proprietary extensions, or simply be entirely free.

There are already open-source software packages available, which are widely used by universities, research organisations and others. Grass, GMT, OSSIM and Mapserver are some of the more widely known spatial information systems applications. Further, open-source software already makes extensive use of shared libraries, some of which can provide Geographic and Information Technology Services identified in the draft ISO Geomatics/Geographic Information standards. There are also many other open-source projects under development that are not specifically related to spatial data that could share functionality with SDIs. The use of distributed component architectures such as CORBA should also facilitate interoperability between these individual open-source development efforts, and also those (including commercial software) using other component architectures such as Microsoft's DCOM architecture.

If the SDI has one defined goal, it is to improve access to the data by all. Open-source software could extend this freedom to the actual applications used to access the data, especially for smaller organizations such as regional bodies, landcare groups and other smaller groups that might not have the resources to implement a solution using only commercial software.

Introduction

One of the great challenges facing practitioners in the field of spatially aware information systems today is finding ways to locate, handle and integrate the wide variety of information that is being generated and being made publically available. Although the term Spatial Data Infrastructure (SDI) may seem to emphasise only the data, the methods used to store, access and manipulate the data are also integral to the implementation of SDIs.

Organisations such as regional bodies, landcare groups, charities and other local community organizations such as agricultural cooperatives, especially those in developing countries, might not have the financial resources or range of expertise needed to implement the integrated systems that are becoming increasingly common for handling spatial data today using only proprietary solutions. Open source software has the potential to make powerful software available to these organizations at a cost that is affordable to them.

The aim of this paper is to provide an introduction to the open-source software model (OSS), and initiate discussion on the potential applications of software based on this model in the implemention of components identified in models proposed for SDIs.

What is open source?

There are two main organisations devoted to promoting the use of open-source software (OSS), the Free Software Foundation (FSF) and the Open Source Initiative (OSI). The difference between these organisations seems to be mainly a matter of philosophy. However each organisation's definition of OSS or "free software" (the FSF's prefered terminology) are to most intents and purposes equivalent. Both emphasize the requirement for compatible licences to make the source code available, and ensure the freedom of users to modify the source code.

The FSF provides a simplified definition of free software as *"Free software is software that comes with permission for anyone to use, copy, and distribute, either verbatim or with modifications, either gratis or for a fee. In particular, this means that source code must be available. ``If it's not source, it's not software.''"* (FSF 2001)

Some of the common open source licences are listed in Figure 1.

Further information on open-source software can be found on the web sites of the Open Source Initiative (http://www.opensource.org) and the Free Software Foundation (http://www.gnu.org/). There are also many other sources of information and commentary about open-source software on the Internet. Kim Johnson provides an excellent review of the open-source software development model, its history and some of the issues associated with development (Johnson 2001).

Smaller organisations, software, and SDIs

The model proposed by the Australian New Zealand Land Information Council (ANZLIC) for a national spatial data infrastructure *"envisages a distributed network of databases, linked by common standards and protocols"* (ANZLIC 1996). However, information systems should not be considered as just data storage and query facilities. Date states that *"a database system involves four major components: data, hardware, software, and users."* (Date 2000) When examining the requirements for SDIs, we should keep in mind that the implementation should be able to be integrated into an organisation's internal systems.

The functionality required could potentially be similar to that of any spatial aware information system, with the additional ability to access a variety of widely distributed datastores. The use of open-source software means that the components of a SDI, such as those used to implement the institutional framework and the clearing house network (such as the components providing information services interfaces), could provide not only the delivery of data but also supply affordable components that would provide smaller organizations with an enhanced ability to utilise the data made available through the SDI, especially when combined with local datasets, to generate and publish new information.

One of the main benefits of such an approach could be in the generation of metadata. This is widely considered to be one of the least glamorous tasks associated with the processing of spatial information, and yet is possibly one of the most critical for effective reuse of datasets, especially where temporal issues are involved. As a result it is frequently ignored or incomplete data is recorded. However much of this onerous task can potentially be hidden from the user by the provision of automated generation and handling of some metadata elements. Open-source software projects are ideal for this as hooks can be programmed

License	Can be mixed with non-free software	Modifications can be taken private and not returned to you	Can be re-licensed by anyone	Contains special privileges for the original copyright holder over your modifications
GPL				
LGPL	X			
BSD	X	X		
NPL	X	X		X
MPL	X	X		
Public Domain	X	X	X	

Figure 1: *A comparison of open-source licensing practices (Perens 1999)*

to directly interface with the metadata application and the internal structure of the application can be examined directly from the source code when necessary, providing the ultimate (though often not very readable) documentation of the algorithms employed in the processing tasks.

Problems with purely proprietary solutions

The rapid increases in performance and storage capacity of modern desktop computer systems are making high performance computing hardware widely available today for a relatively low cost. However there is still a significant expense associated with the use of purely closed source or proprietary software solutions for spatial information sytems that limits the uptake of these technologies by smaller organizations, or restricts access to certain sections of an organisation.

The importance of maintaining data integrity -defined as referring "to the *accuracy* or *correctness* of data in the database" (Date 2000 : 249) - when dealing with any dataset is even more important with those related to SDIs. If smaller organisations are to contribute to such datasets, they are likely to need access to not only desktop GIS packages but also to database management systems in order to provide consistent datasets.

Other factors apart from the initial cost of purchase, installation and integration of the systems should also be included when evaluating software and hardware solutions. These "hidden" costs - also known as the Total Cost of Ownership (TCO) - include the maintenance of operating systems and applications, as well as those associated with management of users, security and data. If these issues are taken into consideration as well, the cost of implementing a system with these comprehensive capabilities using purely closed-source or proprietary software can be well beyond the reach of many organisations, let alone small groups or individuals.

Another problem with proprietary software packages is the potential for vendor lock. Proprietary applications may lock customers into a certain suite of software as converting datasets from one format to another can be a non-trivial effort. It is a common practice for software manufacturers to develop proprietary file formats and not reveal the structure of such formats to keep a competitive edge over other offerings. This creates a major barrier when a data warehouse thinks about changing software and therefore file formats. Many commercial applications support the import of data provided in standard interchange formats, however the ability to export data in such a format may be non-existent, poorly implemented or documented, or the non-intuitive to use. Further, there may be little or no commercial incentive to provide these export capabilities.

There is also the issue of orphaned applications. Commercial interests may lead to development and support of a project being discontinued due to reasons such as financial difficulties, changes in management priorities or the loss of key personnel in the development group and/or management. There is also the danger that in extreme cases these could result in the loss of the code base, preventing the possibility of future maintenance and development efforts.

Fairall (2001) notes that land information systems may only be of benefit to large-scale agri-business due to the significant levels of investment required to set up the information technology infrastructure. It is also noted that "The only other way it can be made to work is to go back to the idea of farmer's co-operatives, in which large numbers of farmers can aggregate some of their technology requirements..." However. open source software, especially when combined with co-operatives, might be able to offer a third alternative.

How open-source can help

Application type	*Price range*	*Software*
High end GIS/RS	USD 10 000 to USD30 000	ArcInfo
		ArcGIS
		Genasys
		ENVI
		ERDAS Imagine
		ER-Mapper
		ArcView extensions
Low end GIS/RS	USD 1 000 to USD 3 000	MapInfo
		ArcView base
		ERDAS Imagine Essential
Database backend	USD15 000 (1 processor)	Oracle
	USD10 000 (1 processor)	Oracle spatial extender

Figure 2: *Costs of selected proprietary software used by SDI data processing*

The Open-Source Software Movement

One of the aims of the open-source software movement is to make powerful software available at a lower overall cost than would otherwise be the case. It offers the potential to provide affordable components for these resource-poor organisations.

Open-source software also has many other possible benefits:

- "Given an infinite number of monkeys..." - open source encourages the sharing of ideas and expertise between projects. Existing software components can be enhanced by the ability to modify and extend the source code of an application to provide new or improved functionality if necessary. This makes the provision of customised solutions much easier to implement, as there is no need to "reinvent the cart" in order to add a suspension system. The problem of vendor lock can also be avoided as developers are free to extend the export functionality.
- The corollary to this is that, because the actual data structures and methods are available for examination by developers and users, problems with the software are much easier to track down - "Given enough eyeballs, all bugs are shallow."(C&B rule 8). This also has implications for issues related to security – an increasingly prevalent problem in today's world. The correctness of algorithms employed in software can also be verified as they are no longer a "black box", as is the case with closed-source software.
- Orphaned applications are likely to be less of an issue as the source code is available. Therefore the application is independent of any one entity, and so is not subject to a single point of failure. There are also implications for digital archaeology – the ultimate documentation for data formats is available in form of the source code itself.

There is also scope to significantly reduce the costs associated with systems management services if using an open-source operating system such as the Debian GNU/Linux distribution. This distribution has an advanced package management (dpkg) and distribution (apt-get) mechanism, which can also be used to provide software packages customised for the local environment when combined with other tools available in the distribution. There are also many other tools for systems management services available.

Some open-source projects relevant to SDIs

There are already many open source projects related to the handling of spatial data. These range from powerful applications through to individual utilities providing very specific functionality (such as libraries providing support for reading and writing a single data format). Development of these is occurring through the involvement of a wide variety of organizations, including businesses, government agencies, universities, and individual developers.

In addition there are many other applications and libraries that can provide information technology services relevant to the architectural reference model defined in the draft ISO Geographic Information – Reference Model standard (19101).

Spatial information services

A comprehensive list of open-source projects related to spatial information systems, many of which offer functionality useful to SDIs, is beyond the scope of this paper. However more information regarding these open-source projects can be found at one of the portal websites devoted to this speciality, such as http://www.freegis.org/ or http://www.remotesensing.org/. Some of the projects and their properties that might be relevant to SDI implementations are outlined below.

The extent of support for spatial data standards varies greatly between the various projects. Some are aimed at reaching full compliance with the relevant standards, while most of the others have at least some support for the exchange of data using standard interchange formats even if they have no direct internal support for a specific standard.

Information technology services

There are also many open-source projects available that can provide Information Services Interfaces and Model/Information Management Services as defined in the ISO Reference Model. A brief survey of some projects relevant to SDIs follows.

Project	Geographic information service supplied	Support for Standards	Licence
Mapserver	Web mapping services	OpenGIS	BSD style
Geotools	Geographic information services	OpenGIS	GPL
OSSIM/FeatureX	Image processing services	Import/Export	GPL/LGPL
GRASS	Geographic information services	Import/Export	GPL/LGPL
GDAL	Information management services	OpenGIS	X/MIT style
PostGIS	Information management services	OpenGIS	GPL
Geotrans	Coordinate transformation services	Not known	Public Domain?
Proj	Coordinate transformation services	Not known	X/MIT style
FMaps	Metadata services	ISO	GPL

Figure 3: *Some of the open-source spatial information projects relevant to SDIs*

Database management systems

Database technology is at the core of the SDI. There are numerous open-source projects currently developing database management systems. However, not all of these are currently suitable for use in SDIs. This is due to the complexity of the conceptual data schemas proposed in the Draft ISO 19100 series of standards, together with the importance of features for ensuring data integrity (such as support for transaction rollback, triggers, constraints and referential integrity). Some well known open source projects that show potential to satisfy various needs of SDI implementations are outlined below. However it is likely that a mixture of these could provide a framework for SDI development, with different tasks being served by the most suitable application for that role.

PostgreSQL is a database management system widely used in applications where data integrity is considered to be of major importance. It features an extensible architecture, based on the object-relational data model, that allows the implementation of user defined types.

The PostGIS project adds support for the storage of spatial data to PostgreSQL and is aimed at compliance with the Open GIS Consortium's "Simple Features for SQL" standard. In effect, PostGIS "spatially enables" the PostgreSQL server, allowing it to be used as a backend spatial database for applications, much like ESRI's SDE or Oracle's Spatial extension. The ability to act as a datasource for Mapserver is a recent addition to its capabilities.

Other current development efforts associated with PostgreSQL include the implementation of:

- a full text indexing and search service (OpenFTS),
- database replication capabilities, and
- support for SQL information schemas.

However, like most other relational database systems, PostgreSQL is not perfect. There are potentially some problems for highly object-oriented data schemas in the way types, complex objects, tables, and inheritance are implemented in the current system (Date 2000 : 865-879). At present it is unclear what implications, if any, these might have for implementing SDIs.

The Predator object-relational database management system has recently been released under a general public licence. It is implemented as a value added server on top of the Scaleable Heterogenous Object Repository (SHORE), an object-oriented database that was used as the storage manager for the Paradise project (a parallel database system for GIS applications) developed at the University of Wisconsin. To what extent the distributed capabilitities of the Paradise code have survived in the publically available SHORE Storage Manager is at present being researched. Although it currently has limited functionality due to its infancy, the authors feel that Predator's modular architecture makes it worthy of further study.

MySQL is a relational database management system that has a reputation for being fast and is widely used for simple applications. However, when last evaluated it had only limited support at best for some important features of the relational data model (such as data integrity). As a result, it is probably of limited relevance to core elements of SDIs in its current form.

In the long term Predator may turn out to be the most suitable project for the core of SDIs, especially when SHORE's former relationship with the Paradise project is considered. However, if a relational data model is being used PostgreSQL currently provides a powerful alternative to proprietary database applications.

Other data storage and encoding related projects.

There are many other database projects available under open-source licences, including some using alternatives to the relational data model, such as object-oriented databases. A wide variety of database interfaces are available supporting standards such as the JDBC and ODBC specifications.

Extensive support is also provided by numerous projects for the interchange and storage of data encoded using various markup languages including the text-based SGML and XML specifications, and also newly-emerging specifications such as the XML Schemas and the Resource Description Framework (RDF) which are "data type aware" and therefore suitable for handling data types other than plain text.

These developments, especially when combined with the use of distributed component architectures such as the Common Object Request Broker Architecture (CORBA), promise greatly enhanced abilities for the interchange of data between organisations.

Modelling tools

The ArgoUML and Dia projects both provide the ability to create and store UML models. These tools would naturally lend themselves to use in the definition and exchange of application profiles. However ArgoUML also has other features that could be of great benefit, such as "cognitive support" in the form of design critics for issues associated with the design of application and data schemas at all levels: conceptual, logical and the implementation or physical.

Other services

A wide variety of word processing packages, spreadsheets and other mathematical and statistical services, web servers, graphics applications, plotting tools, package management and security services are also available under open-source licences.

Distributed spatial information systems development

There are already open-source projects being used for implementing components of several SDI implementations that the authors are aware of.

In NSW, Australia, there are several existing projects currently under development. The Inner Metropolitan Regional Organisation of Councils (IMROC) in Sydney, in association with the CSIRO, are developing a middleware application that is capable of delivering spatial information across the Internet. This application can display vector graphics using the Scaleable Vector Graphics (SVG) format from diverse data sources. (CSIRO 2001)

Another NSW project is that being developed by the Community Access to Natural Resources Information (CANRI) in conjunction with Social Change Online. The CANRI implemented a system that delivers raster imagery and maps. It utilizes open-source projects including Mapserver and the Perl scripting language together with proprietary components. There are also extensive plans for further development (CANRI 2001).

The South Pacific Applied Geoscience Commission (SOPAC) is sponsoring development of the Wide Area GIS (WAGIS) project (Martin 2001). This project is developing a meta database to be used in-house and by member countries. SOPAC is a regional organisation with 19 Pacific Island Member Countries (including Australia and New Zealand).

WAGIS was first developed to answer an in-house need to store GIS data layers. The standard software for GIS work in the region is MapInfo. It was therefore decided to develop an interface to MapInfo to store the data layers in a common directory structure and the associated metadata catalogue in a relational database. The metadata catalogue follows the ANZLIC metadata standard v1.0 with very few local modifications to allow synchronisation of metadata between several sites. Following the SOPAC GIS Policy paper all development is released under the GPL/LGPL licences unless otherwise specified. Therefore it is an open-source interface sitting on top of two proprietary products, MapInfo and Microsoft SQL Server v7.0.

The South Pacific Regional Environment Programme (SPREP) is producing a State Of the Environment (SOE) report over the next two years. It was decided to build upon the WAGIS experience and develop an interface using Microsoft Access with an optional SQL Server backend. The system will follow the ISO 19000 series of standards, as WAGIS is still in the testing phase and a rewrite of the database could prove beneficial for all parties.

The experience with WAGIS shows that to establish an SDI in the Pacific Island Countries is a long process, as all stakeholders needs to buy-in. To increase the chance of success, the system must be as simple as possible with a coordinating agency, which keeps the momentum on the project.

Finally, the European Union has recently decided to fund SOPAC for an Island System Management project for the next 5 years. This project includes data sharing components amongst the countries where the project will be implemented. The use of open-source applications to sustain this SDI will prove themselves essential to the establishment of a distributed geographic information system.

Some issues associated with open source software projects

The following are personal observations on some of the problems faced by open-source software developers, based on the authors experiences evaluating the potential of existing projects for implementing an open-source metadata application, from observing discussions on the development mailing lists belonging to a variety of projects and personal communication with other developers. It is the author’s hope that by raising these issues here a dialogue can be initiated between the various projects and other interested parties on methods that can be employed to alleviate these problems.

Scale of projects

Open-source projects, particularly major projects with scopes as large as that of GRASS, can be daunting to the new developer. Those projects relevant to SDIs are especially susceptible to this due to the number of interdependent technologies involved. A typical application might involve user interface toolkits, database management systems, datastore interfaces and a variety of communications technologies. Unless the developer’s interests are highly specific, even finding a place to start can be difficult without an overall view of the application’s architecture and a knowledge of the technologies involved.

Coordination and design issues

One of the current problems with open-source software development model is due to the different needs and priorities of the various projects. The necessary functionality for dependent projects may only be planned or partially implemented. This is especially the case for such complex applications as spatial information services. In many cases, development is currently taking place in a largely piecemeal fashion with limited coordination between projects - although fortunately coordination between the various projects is becoming more common.

Access to Standards

The fact that some standards are not publicly available can be a problem for open-source software projects. Examples of this include the Geomatics/Geographic Information series of standards and the various SQL standards published by the International Standards Organisation.

Open-source software projects frequently involve volunteer developers and are frequently initiated by individual developers, who may not be able to get access to these standards – which are crucial for project design.

Adoption of standards

Even if the standards are made available, there may be reluctance to adopt standards – either due to the amount of effort required to "retro-fit" support for standards into the code base or for other reasons.

Client resistance to adopting open-source software.

External consultants may have difficulty persuading clients to accept solutions using OSS due to a perception of the risks involved: "If a small group of employees spend a bit of time doing something behind the scenes using OSS and it does not work then management can excuse it as "testing" or a "feasibility study". However, if they hire me to build it and it doesn't work they have to explain why they have paid $X,000 for a lemon." (Hallam 2001).

Licence wars

A frequent source of (sometimes heated) discussion on development mailing lists is the choice of licence for a project. Companies tend to prefer one of the BSD, X or Apache style licences, which allow private modifications to the source code, over the "copylefted" licences such as the GPL. However the authors cannot see how the use of a non-copyleft licence is in the interest of smaller development organisations, such as private service companies or volunteer developers, as these licences allow other (larger) companies to take and extend existing development without an obligation to contribute anything in return.

Indeed, one of the main objectives of the copylefted licences is to foster collaboration between different developers and projects by preventing the situation outlined above. Therefore the authors feel that use of the copylefted licences should be encouraged for open-source projects related to SDIs. This is keeping with the spirit of SDI.

A suitable compromise between the various interest groups (proprietary and open-source developers) might be a wider adoption of the LGPL, which allows the linkage of open-source software into proprietary executables. However this is a contentious issue which merits further discussion.

Availablility of resources

Small or part time groups of developers may not have the resources that are available to large commercial projects. Except for those fortunate individuals that have independent means or sympathetic employers, there often has to be a trade-off between the time that can be devoted to development, amount of sleep and having enough money for living expenses and development infrastructure (e.g. software, resource materials, and hardware). The development of development tools that are freely and cheaply available can help to alleviate these problems.

No such thing as a free lunch

A common misunderstanding related to open-source or "free" software is that it is available at no cost. However, if such an attitude is commonly adopted, it is unlikely that open-source projects will survive. Instead, there is a social obligation to provide some return to developers. This could take the form of direct financial support and/or "in kind" assistance.

Financial support can take such forms as purchasing a support contract, contracting developers to implement new features, or by making a payment proportional to the benefit obtained and the organisations' financial capacity. Alternatively, equipment and other resources can be donated to developers.

Another alternative is for users to provide "in kind" support such as making personnel available to participate in project development. This is especially suitable in the case where an organisation may have positions with an irregular or seasonal workload.

A comprehensive discussion of these issues is beyond the scope of this paper, however there are many sources of information related to the economics of OSS available on the Internet. Good starting points are the OSI and FSF websites and there are also numerous bibliographies devoted to open-source software, including business and economic aspects.

Future Directions

One of the major benefits of the push toward SDIs is the increasing levels of cooperation between various data providers. It is the hope of the authors that increased cooperation between the various open-source projects will also occur. The use of OSS to provide components for SDIs could be a catalyst for this process.

The creation of a steering body or organisation devoted to coordinating development efforts and encouraging the adoption of standards would be of great assistance in furthering this process. This role could be taken on by one (or more) of the existing agencies or companies associated with SDIs or open-source development.

A good starting point would be a project devoted to the implementation of an open-source metadata catalogue. In common with many proprietary systems, many of the open-source projects currently lack extensive support for the handling of metadata. There is scope here for cooperative development between the CANRI projects and the WAGIS, Fmaps, Geotools, PostGIS, and Predator projects.

Another problem is the lack of a copylefted C++ vector library aimed at compliance with a recognised standard. Java libraries for core vector data model objects are under development (Geotools), but there is no equivalent C/C++ library. Some alternatives are reviving the orphaned Geographic Foundation Class (GFC) library, implementing a new library from scratch and/or investigating the possibility of relicencing the OGR (Simple features) component of the GDAL library under the LGPL.

Interoperability between projects and with proprietary software is also an issue that needs to be investigated. Providing CORBA services around existing projects may be one way of achieving this.

Finally (or firstly), a survey of the needs of organisations (such as Land Care groups and small councils) should be undertaken to determine their perceived requirements. This can then be used as a guide to determine what is actually needed and establish priorities for implementation of features.

Conclusions

The authors feel that open-source software provides great potential to make available components for SDI implementations that are affordable by resource-poor organisations, extending the concept of SDI by also providing the means to manipulate the data made available through SDI initiatives. Many basic building blocks for SDIs are already available, while others are undergoing rapid development. Existing OSS projects have the potential to provide geographic information and information technology services to organisations implementing SDIs, and SDI implementations could in turn provide a framework to assist the development of OSS projects.

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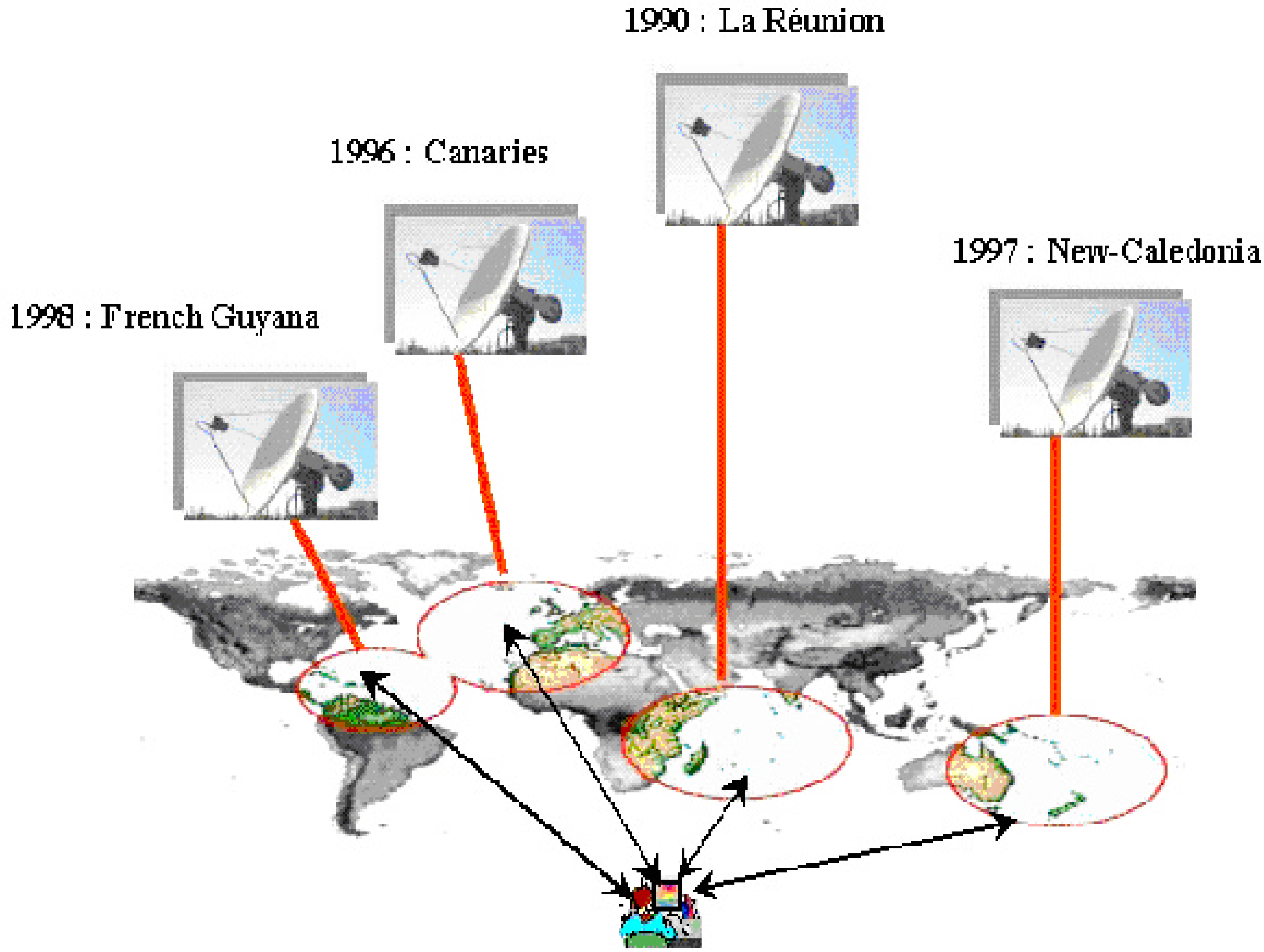
Low-Resolution Oceanic Information System in Real Time to Understand, Manage and Predict

Didier Lille, IRD

Introduction

Today (June 2001), the stations for the **A**ssisted **S**urvey of the **E**nvironment by **S**atellites (**SEAS** station) are networked, driven by the IRD centres (Guyana, New-Caledonia, La Reunion) or the partnership organisations (ULPGC/ Canaries). These stations are equipped with a system of reception for terrestrial as well as oceanic environmental satellites (NOAA, SEASTAR). With a kilometric and multi-daily resolution, each of these stations covers an area greater than a circle of 5000km of diameter including the several sites of national and international research programs.

In environmental research, data is invaluable, and their loss and lack is costly. Beyond the structuring of the research, the acquisition of data from modern observatories like the SEAS stations is a worthwhile investment and a basis for development for the environmental research programs. These data, or more exactly these measurements of environmental parameters, are a global heritage: the satellites are American (NOAA/NASA), the acquisition is French (SEAS), the archiving European (ESA), the principal interested parties are our partners (Madagascar, Brazil, South-West Pacific Countries…)



The Concept

We assist in increasing awareness in the society concerning the quality of life, and particularly the environment around the coastal zone. This awareness will lead decision makers and experts to search for updated and validated information in a real and complex environment. In this context, the technologies linked to remote sensing and information systems play the role of first importance, because the image is not only a precious source of information but also a support of communication and even an exhibit.

It is in this context that the ESPACE unit of IRD leads in research and development actions regarding the help to decision and has acquired 10 years of experience through its network of Survey of the Environment Assisted by Satellites (SEASnet); analysed under the following three objectives:

- **To observe globally to understand locally and to manage together**

The observation, the information are the foundation of every strategy. The quality of the observation must be in the repeatability, the precision and the knowledge of the objectivity by all the actors of the studied system. In this context, the quick acquisition of relevant data in an adapted continuum spatiotemporal, aerospace remote sensing appears like one of a modern-key technology. For better understanding of the local evolution of anthropic and natural environments, satellite observations are an essential component by determining the correct spatiotemporal scales. Nevertheless, it is still necessary to integrate competing data, field information, models and the local expertise. So, the aim is really to create a durable and operational system of observation for larger areas and over a long period of time;

- **To create the conditions for emergence of an alternative solution by using the modern systems of observation**

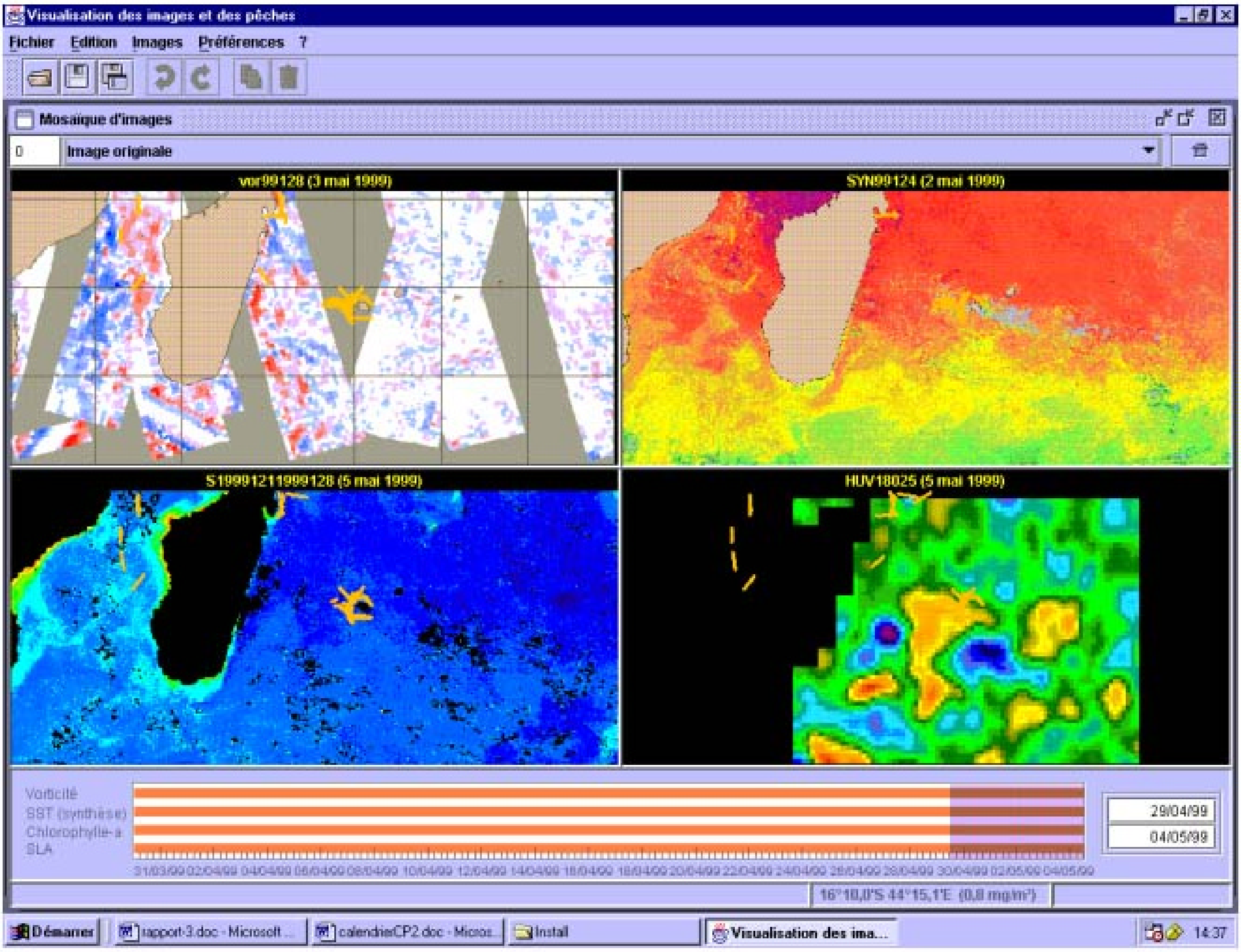


Figure1: *Example of a query interface of the image database - SeasView*

Low-resolution Oceanic Information System in Real Time

The observatory as defined must be fully part of the modern society and give useful products for the stakeholders in the system, who have most of the time a common weakness: the spatial and dynamic knowledge of the costal or high sea "landscape".

- **To inform people locally about the research and expertise**

In fact, the different sites of the network are interfaces between the ones who have the knowledge of environment/resource problems but don't know the new technology and the others who have the technology but bad comprehension of the problems.

The System

The principle of oceanic information system set up in SEAS, especially in the high sea domaine:

- A network of acquisition and automatics treatment (*Figure 2*)
- A multi-site database of images
- Ways of exploitation and spatiotemporal management (*Figure 1*)
- Ways of scientific validation of data
- Interfaces of multi-actors communication
- Ways of telecommunication

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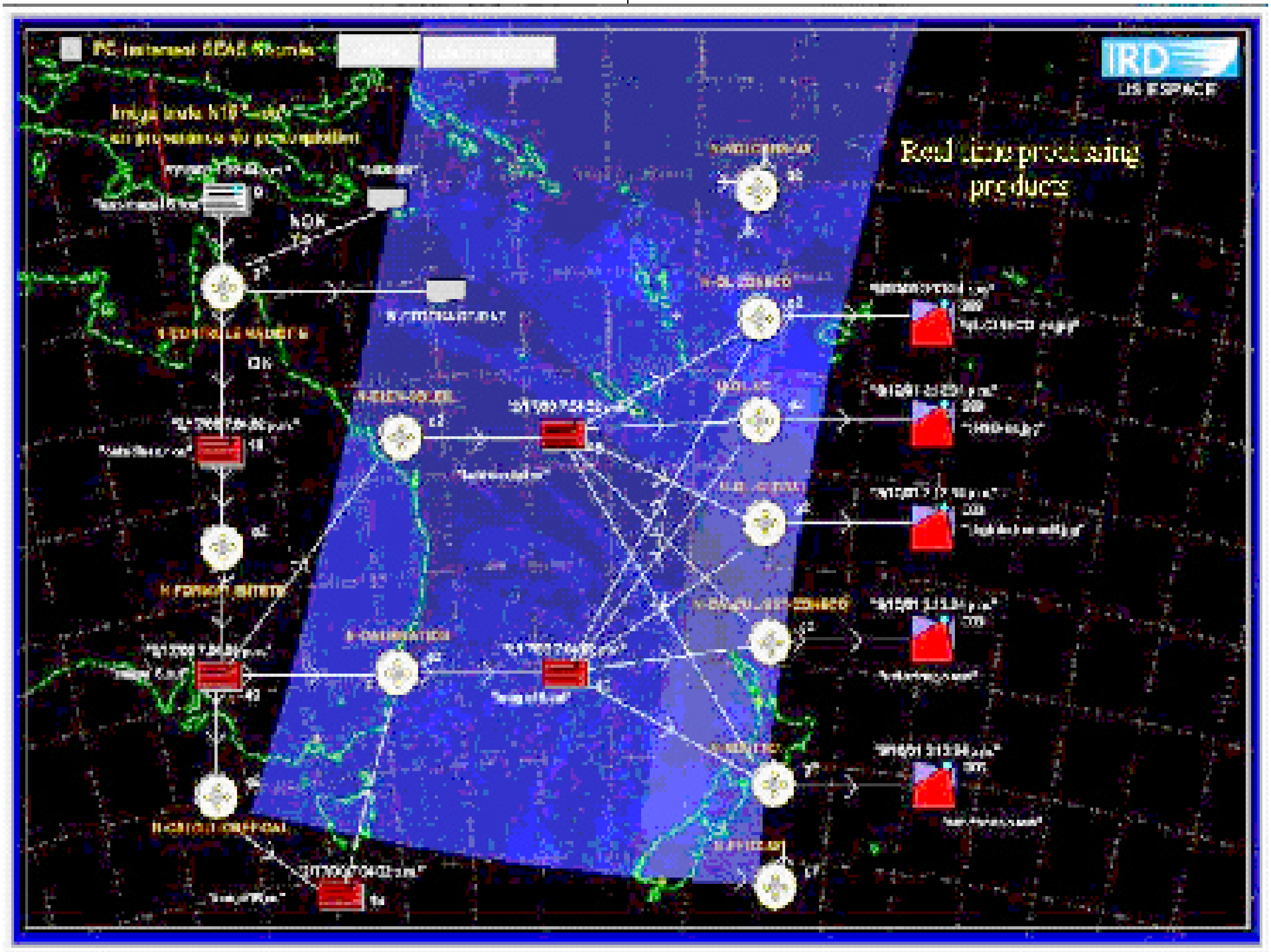
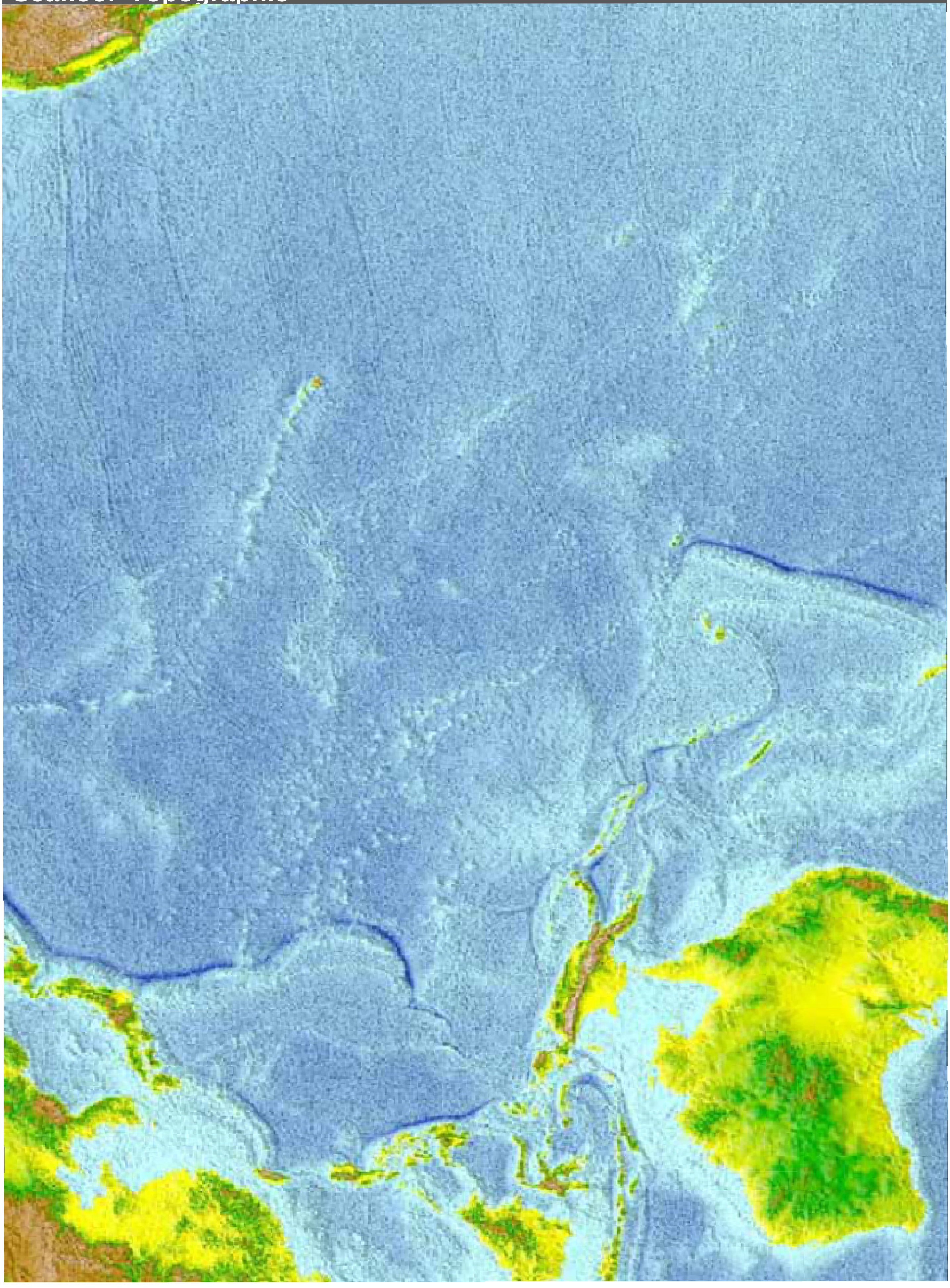
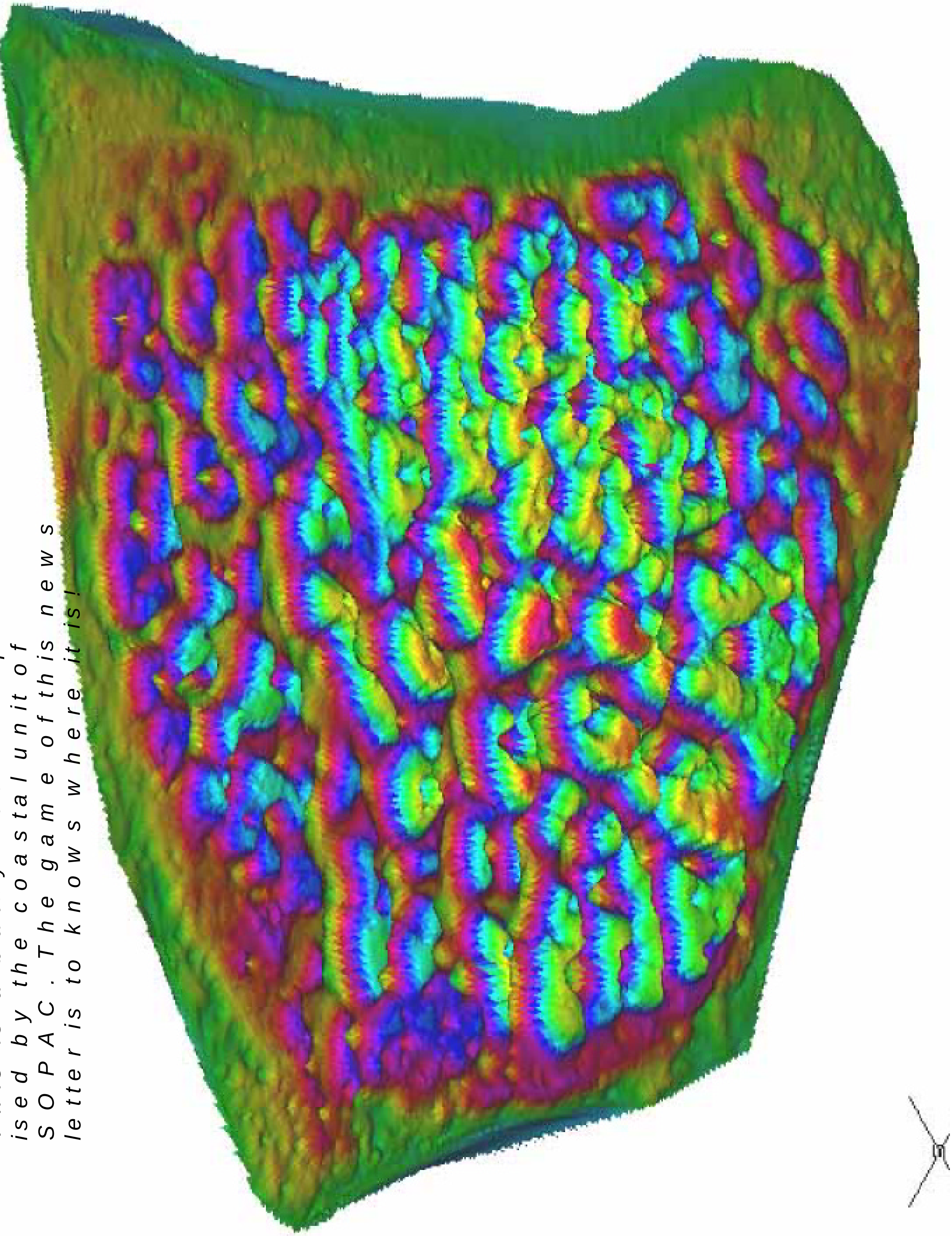


Figure 2: Example of an automatic image treatment flow





This is a bathymetric map real-ised by the coastal unit of SOPAC. The game of this news letter is to knows where it is!